

Expert Report

of

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Ex. 6 Personal Privacy (PP)

Submitted as Public Comment

On the

Docket ID no. EPA-HQ-SFUND-1999-0010

The United States Environmental Protection Agency, Region 8

Notice of Intent to Delete from the
National Priorities List

Operable Unit 1
of the
Vasquez Boulevard and I-70 Superfund Site
City and County of Denver, CO

March 4, 2019

1. INTRODUCTION

I have had the opportunity over the past 18 months to provide my services as a geologist, hydrogeologist and geochemist to United States Environmental Protection Agency Region 8 [USEPA R8] staff through *pro bono* review of USEPA and contractor reports and data on behalf of the USEPA R8's Community Advisory Group [CAG] for the Vasquez Boulevard and I-70 Superfund Site [VB/I-70 Site]. By way of introduction, I include a copy of my professional resume as Attachment 1 to this public comment.

I elect to offer this public comment to supplement my ongoing consultation with the VB/I-70 Site CAG. I do so because I strongly believe that Region 8's Notice of Intent to Delete Operating Unit 1 [OU1]¹ is unjustified, the procedures used by Region 8 are incomplete, such deletion is demonstrably ill-timed, and the basis provided for the deletion is replete with error.

VB/I70 OU1 deletion is unjustified because doing so does not meet the any of the three requirements of 40 CFR 300.425(e).²

Multiple procedural items enumerated by USEPA R8 in the Notice of Intent³ were not done or are incomplete. Item (3) is in error. As of the date of the start of comment period, several documents listed in the online deletion docket (Item (6)), are not accessible and/or not retrievable for public review. Contrary to the reference in Item (6) of "information repositories identified above," no such repositories are identified in the Notice of Intent. Further, information repositories previously used for VB/I-70 Site documents have none of the items of the deletion docket present for public inspection and copying as of the start of the 30-day public comment period.

Documents that are fundamental to evaluating the appropriateness of the Notice of Intent for deletion VB/I70 OU1 are not included in the deletion docket at the start of the public comment period. Perhaps the most egregious omission is that of the Feasibility Study. (The Executive Summary of the Feasibility Study is, as of February 8, 2019, included in the deletion docket as

¹ Federal Register, Vol. 84, No. 25, Wednesday February 6, 2019, Proposed Rules: ENVIRONMENTAL PROTECTION AGENCY, 40 CFR Part 300, [EPA-HQ-SFUND-1999-0010; FRL-9988-92-Region 8]; National Oil and Hazardous Substances Pollution Contingency Plan; National Priorities List: Partial Deletion of the Vasquez Boulevard and I-70 Superfund Site, pp. 2116 *et seq.*

² *Ibid.*, II. NPL Deletion Criteria, pp. 2117 and 2118.

³ *Ibid.*, III. NPL Deletion Procedures, p. 2118.

Document 61, but the Feasibility Study in its entirety is not.) Within the Superfund process, probably the two documents most foundational to appropriate response activities are the Remedial Investigation and the Feasibility Study. Yet, USEPA R8 relies only on the former for its justification of the appropriateness of its proposed deletion.

This deletion is ill-timed because it is known now, from existing information and documentation, that VB/I70 OU1 requires additional and alternative response action(s) to address significant threat to human health and the environment. Further action is appropriate and warranted now; one need not wait for some hypothetical future time.⁴

The basis proffered by USEPA R8 as supporting its Notice of Intent to Delete OU1⁵ is replete with inaccuracies, misstatements, and errors. Beginning with the selection of documents submitted (and not submitted) into the deletion docket, the Notice of Intent, to me, reflects an attempt to justify a predetermined decision rather than a data-based demonstration that deletion is either appropriate, justifiable or protective of human health and the environment.

2. BASES OF COMMENTS AND METHODOLOGY

My comments result from a variety of information sources upon which I have relied. Many of the sources are documents related to the pre-Superfund investigations in the area that would become VB/I-70 OU1, USEPA R8's Superfund investigations prior to the issuance of its Record of Decision [ROD] for VB/I-70 OU1, and USEPA R8 documents related to remedial activities undertaken subsequent to the issuance of its ROD.

I also reviewed USEPA R8 documents related to assessments of VB/I-70 OU1. Such documents include, among others, the VB/I-70 OU1 ROD, the 5-year assessments, the VB/I-70 Consult for Delisting for Lead, an Explanation of Significant Differences, the Final Remedial Action Report, and the Concurrence Letter of the Colorado Department of Public Health and the Environment.

I also reviewed and rely upon documents that, while not categorized by USEPA R8 as pertaining to VB/I-70 OU1, are fundamental to understanding the contamination quantified to date at VB/I-70 OU1 and for understanding the inappropriateness of USEPA R8's response at VB/I70 OU1.

⁴ *Ibid.*, USEPA's Notice of Intent multiply cites 40 CFR 300.425(e)(3), stating "... that the deletion of a site from the NPL does not preclude eligibility for future response actions, should future conditions warrant such actions."

⁵ *Ibid.*, IV. Basis for Intended Partial Site Deletion, pp. 2118, *et seq.*

These include documents from the Administrative Record of VB/I-70 Operating Unit 2 [OU2] (e.g., old maps of North Denver, the periodic publication *Denver Municipal Facts* (1909 – 1928) by City and County of Denver [CCoD], and old aerial photos of North Denver) and reports pertaining to Colorado Department of Transportation [CDOT] characterization of the I-70 corridor through the years.

I have heard and rely upon oral comments and presentations presented at various CAG meetings from CAG members, public participants, Agency representatives (USEPA R8, CDPHE, CCoD and CDOT) and their contractors, as well as USEPA tutorials on how the Superfund process works, presented outside of CAG meetings.

Some of these sources are cited specifically in the text below describing my understanding of, and public comment about, the proposed deletion of VB/I70 OU1. The complete list is found in Attachment 2 to these public comments. I reviewed remote imagery of the site via *Googletm earth* both for current imagery and historic imagery that is available on the *View/Historical Imagery* menu.⁶ I have reviewed information available in Denver Property Taxation and Assessment System for selected properties assessed and/or remediated as part of VB/I70 OU1 activities.⁷ By auto and/or on foot I have toured many parts of OU1 over the past two years.

Finally, I draw upon my academic and industry training in geology, hydrogeology and geochemistry and my experience from more than 40 years of professional practice as a geologist, hydrogeologist and geochemist to form the opinions and comments that I offer.

3. GEOLOGIC AND HYDROGEOLOGIC SETTINGS

VB/I-70 Superfund Site is located in north Denver along both sides of Interstate 70 and on both sides of the South Platte River. VB/I-70 OU1 predominantly lies east of the river includes the historic towns of Elyria and Swansea (now neighborhoods of CCoD) and all or portions of the CCoD neighborhoods of Clayton, Cole, Five Points and Curtis Park. West of the South Platte River, VB/I-70 OU1 covers a small corner of the historic town of Globeville (now a neighborhood of CCoD), located southwest of the intersection of Interstates 70 and 25, bounded

⁶ Images were available from June 1993 into May 2018.

⁷ E.g., <https://www.denvergov.org/property/realproperty/summary/160763799>

to the north by I-70, to the east and south by I-25, and to the west by the rail lines immediately east of Inca Street.⁸

3.1 *Geology*

What is known about the geology at VB/I-70 OU1 is known only from studies independent of the Superfund investigations. The Superfund program produced no geologic information within the area of VB/I-70 OU1 beyond widespread analysis of the concentrations of lead and arsenic and much more limited analysis of other RCRA metals, predominantly from the top two inches of soil of only residential properties, school yards, and parks.⁹ The remedial actions also produced no geologic data.

The portions of VB/I-70 OU1 on the east side of the South Platte River are underlain by native unconsolidated sediments that are predominantly alluvial (stream- or river-lain) floodplain sediments of the present South Platte River or those of its recent past and/or of lesser streams that drain or drained northwestward across the area of OU1. Overlying all but the youngest of the alluvial sediments are native unconsolidated sands and silts deposited by wind redistribution of previously deposited alluvial sediments. The Globeville portion of VB/I-70 OU1 west of the South Platte River is generally underlain by native unconsolidated alluvial sediments on river terraces above the South Platte River, terraces that represent earlier history of river.

Underlying the unconsolidated sediments associated with the South Platte River and its tributary drainages is the consolidated bedrock of the Denver Formation, a formation that contains the Cretaceous-Paleogene boundary and extinction event. The Denver Formation under VB/I-70 OU1 is comprised predominantly of layers of shale and siltstone, with occasional beds of sandstone.

One of the streams most significant to VB/I-70 OU1 is Montclair Creek. The topographic basin of the historic Montclair Creek drainage, with its associated alluvial sediments, underlies most of the VB/I-70 OU1 area that is east of the South Platte River. Montclair Creek existed as a single channel within a floodplain of alluvial sediments from near the southeast corner of City Park to

⁸ Vasquez Boulevard and I-70 Superfund Site Boundary Map, including boundaries of OU1. January 14, 2011.

⁹ As described further in these comments, eight residential properties were investigated to a depth 12 inches and the Phase I investigation analyzed one sample per residence at a depth of from six to 10 inches.

its confluence with the South Platte River¹⁰ northwest of the National Western Stock Show complex. Southeast of City Park, Montclair Creek bifurcates into two tributary headwater streams.¹¹ A portion of the eastern most VB/I-70 OU1 overlies the western edges of the Sand Creek drainage basin and alluvial sediments, east of the divide with the Montclair Creek Basin.

Generically, an alluvial flood plain is a gently sloping, often slightly undulating, land surface formed by the deposition of a significant thickness of unconsolidated sediments transported by rivers and streams passing across or down the plain. An alluvial plain typically has a regional slope in the direction of and with the same approximate tilt as the fall of its major river.

Native sediments deposited on an alluvial plain can range from very coarse (beds of boulders in some cases) to extremely fine (clay-sized particles) with intermediate grain sizes of silt, sand, and gravel. Deposition by streams and rivers tends to segregate sediments of similar grain size, depositing the sediments in discrete units or beds comprised of sediments of common size; *i.e.*, clay units, sand units, or gravel beds. These units individually do not extend over broad areas and tend to be local, but often intersect with adjacent units of similar grain size. Generally, native sediments deeper into the plain are coarser grained than those near the surface.

3.2 Hydrogeology

What is known about the surface or subsurface hydrogeology at VB/I-70 OU1 is known only from studies independent of the Superfund investigations. The Superfund program produced no hydrogeologic information within the area of VB/I-70 OU1. The remedial actions also produced no surface or subsurface hydrogeologic data.

Under natural conditions, the hydrogeology of an alluvial plain is a closely integrated system of surface and groundwater flows. The flow of surface water across an alluvial plain is readily apparent in the main river and any tributaries to it. Less apparent, but equally significant, is the flow of groundwater through the alluvial sediments. Least apparent, but sometimes most significant, are the exchanges of flows between surface water and alluvial groundwater.

¹⁰ Figure 3.2 Geologic Overlay Map 1979, p. 3-2, from Chapter 3 History of the Watershed, Lower Montclair Watershed Outfall Systems Plan, Enginuity Engineering Solutions, DRAFT - May 2016. Figure is of digital overlays of streams from 1862 and 1899, Geologic Map of Greater Denver Area (1979) by U.S. Geologic Survey, and a street map of Denver.

¹¹ *Ibid.*

Under natural conditions, the down-valley flow of water in a stream or river is visibly evident, as either continual flow or intermittent flow. The groundwater flow through the saturated portion of the alluvial sediments (the alluvial aquifer), though invisible, is also dominantly down-valley. Although the flow rate in the alluvial aquifer is much slower than that in the river, the hugely greater volume of the alluvial aquifer, compared to the river channel, allows the alluvial aquifer to convey as much or more water downstream as does the river under many conditions.

In addition to down-valley water transport, under natural conditions there is cross flow between the river and the alluvial sediments. At places or during times of low river levels, groundwater from the alluvial aquifer will discharge into the river through the river's banks and bottom (base flow). At places or during times of high river levels, surface water in the river will flow into alluvial aquifer through the river's banks and bottom (recharge). Consequently, depending upon time and/or place, the down-valley flow in the alluvial aquifer may be obliquely toward or away from the river. The movement of surface water and groundwater in the valley of an alluvial plain are so closely related that in western water law they are considered a single source of water.

There is little left to the surface hydrology of the South Platte River alluvial plain within Denver that retains natural conditions. The flow in the South Platte River through Denver is tightly controlled by dams on Cherry Creek and at Chatfield Park on the South Platte River itself. Throughout Denver and certainly across the VB/I-70 Superfund site, the surface drainage to the South Platte River from its alluvial plain is urbanized storm water flow that is not reflective of natural conditions, and it has been that way for generations.

Groundwater flow in the alluvial valley of the South Platte River is less modified than the surface water flow. There certainly have been changes and some of these are discussed further into these comments. However, the alluvial aquifer still exists and continues to transport its resource water down the South Platte River valley and into the South Platte River itself.

Under the bulk of the VB/I-70 OU1 area east of the South Platte River, the portion of the South Platte alluvial aquifer that lies beneath historic Montclair Creek has been compromised by urbanization and storm water management features that create artificial discharge and recharge areas that modify the flow within it. But unlike Montclair Creek itself, the groundwater in the Montclair alluvial aquifer is still a water resource to be protected.

As with the geology of the unconsolidated sediments underlying VB/I-70 OU1, there is remarkably little characterization of the groundwater hydrology beneath VB/I70 OU1. Systematic mapping of the Montclair Creek alluvial aquifer, of flow through it, or of groundwater quality within it seems never to have been done. The investigations performed for VB/I-70 OU1, by design, precluded any characterization of groundwater quality, quantity or migration. USEPA R8 instituted this preclusion in spite of mobile target contaminants in surface soils directly overlying the alluvial aquifer with no intervening barriers to downward migration.

Similarly, infrastructure construction by CDOT and CCoD routinely ignore groundwater characterization of the alluvial aquifer, characterization that is fundamental to protecting this groundwater resource. Notwithstanding city, state, and federal agency avoidance of characterizing the Montclair basin groundwater resource, piecemeal data do document that resource water does exist in the Montclair alluvial aquifer and that resource water does flow under VB/I-70 OU1 and to the South Platte River.

Before urban development of the area of VB/I-70 OU1, the mapped confluence of Montclair Creek with the South Platte River was near the center of the west side of Section 14 of Township 3 South and Range 68 West.¹² Based upon this 1861 mapping, the historic confluence was approximately at the projection of 50th Avenue to the South Platte River. A survey of river elevations done in 1957 shows the elevation of the South Plate River at that location to be approximately 5130 feet.¹³ This river elevation is expected to be similar to the contemporary river elevation.

In 2016, CCoD measured groundwater elevations at the south end of City Park Golf course in anticipation of excavating a water course into the groundwater resource of the Montclair alluvial aquifer, tapping the aquifer to generate surface water flow.¹⁴ The reported groundwater elevation at the south side of the golf course was 5242 feet and that at the northwest corner of the golf course was 5228 feet, a drop of 14 feet to the north-northwest over a distance of 1,505 feet

¹² Figure 3.1 Historic Map 1861, p. 3-1, from Chapter 3 History of the Watershed, Lower Montclair Watershed Outfall Systems Plan, Enginuity Engineering Solutions, DRAFT - May 2016.

¹³ Michael A. Stevens, 1983, Stream Stability Investigation, South Platte River, Chatfield Dam to Baseline Road, Final Report, Prepared for Urban Drainage and Flood Control District, Denver CO.

¹⁴ Figure 3 Groundwater Elevation Measured on 9/27/2016, Pinyon Environmental, Inc, Subsurface Investigation Report, Platte to Park Hill Drainage Project – City Park Golf Course Redesign, Revision I, prepared for City and County of Denver Department of Environmental Health, October 21, 2016.

horizontally, a gradient of 49 feet per mile. The elevation drop in the Montclair alluvial aquifer between the south side of the golf course and the historic confluence with the South Platte River is 112 feet over a distance of 14,110 feet horizontally, a gradient of 42 feet per mile.

Given the sparsity of data, the ranges of dates among the data, and the lack of area-wide characterization, these two gradient computations are remarkably consistent with expected gradient patterns for an alluvial aquifer. They strongly support the expectation that saturated sands within the Montclair alluvium constitute an alluvial aquifer that underlies VB/I-70 OU1. Within that aquifer, resource groundwater moves beneath the operable unit toward the north northwest, conveying renewable water that is tributary water to the South Platte River.

3.3 *Anthropogenic Modifications*

3.3.1 Geology

The geology of the area overlain by VB/I-70 OU1 has been significantly modified over the 150 years since start of the migration of Euro-Americans into the area in the mid-1800s. Until 1861, when the Colorado Territory was defined, the migrant caravans had little impact of the geology beneath VB/I-70 OU1. Soon thereafter, that changed.

In 1870, two railroads constructed lines across the area of VB/I-70 OU1. The Denver and Pacific Railroad came in from the northeast, along the south side of the South Platte River valley, and the Kansas and Pacific Railroad came in from the east. Both rights of way are now parts of the Union Pacific and the latter is used in part for Denver's A-Line to Denver International Airport. These lines met at a facility called Jersey Junction, squarely over the channel of Montclair Creek, approximately at today's geography of 43rd Avenue and Williams Street.¹⁵

The new rail lines did not build trestles across the Montclair Creek basin or bridges across the creek itself. Rather, each built an embankment above the basin and through the creek and laid tracks atop the embankment.¹⁶ These two railroads were followed by at least three others by 1874, each of which filled portions of the Montclair Creek basin and Montclair Creek itself to

¹⁵ Figure 3.3 Montclair Basin Historic Railroad Blocking, p. 3-2; Table 3.1: Railroad Crossings of Montclair Creek (1870), p. 3-2; and Section 3.5c Completion of Initial Railroad Crossing of Montclair Creek (1870-1874) p. 3-3. From Chapter 3 History of the Watershed, Lower Montclair Watershed Outfall Systems Plan, Enginuity Engineering Solutions, DRAFT - May 2016.

¹⁶ *Ibid.*

connect at Jersey Junction.¹⁷ The embankments built in the early 1870s likely used native soils and sediments; it was before significant industrial waste streams would have existed for fill. Since Montclair Creek was intermittent, the embankments interfered with stream flow only following rain events or snowmelt. The natural sediments below the embankments were sufficiently permeable that dammed water would slowly infiltrate the ground, flow under the railroad embankments, and, either as groundwater or re-emerged stream, continue to the South Platte River.

Although the water and the railroads could coexist, the construction of the embankments had a profound impact on the subsequent development of the area that eventually became VB/I-70 OU1. The floor of the Montclair Basin was now episodically a pond or a swamp. Development of the area did continue, but to do so residential and industrial areas had to be filled to levels above the impounded storm and snow-melt flows.

Through the subsequent decades and generations, the elevation of the land that became the neighborhoods that are part of VB/I70 OU1 was raised. It was raised wagon load by wagon load, truck load by truck load, to the elevation of the railroad embankments. Once filled, urban infrastructure of drains, sewers, roads, water lines, gas lines and railroad crossings could be built. But the infrastructure was built not upon the Montclair Creek valley, but upon the fill brought into the valley, the fill that obliterated the Montclair Creek valley. And in those neighborhoods that were lifted, the residences, the businesses, the parks and the schools are built not upon the geology of alluvial sediments, but upon the geology of random loads of the miscellaneous fill.

The artificial fill of the Montclair Creek basin is of variable thicknesses. In the core of the basin, over historic Montclair Creek itself, the fill is up to several tens of feet and it tapers to zero at the flanks. One recent soil boring, upstream of the railroad junction, at the west end of City Park Golf Club, penetrated fill that was five feet thick.¹⁸

Artificial fill deposits have no systematic or natural patterns of placement. Their placement represents the immediate availability of a fill material and the need for, or opportunity of, a place

¹⁷ *Ibid*, Section 3.6, p. 3-3.

¹⁸ Appendix A Soil Boring Logs with Well Construction, Log for Boring PZ03. Pinyon Environmental, Inc, Subsurface Investigation Report, Platte to Park Hill Drainage Project – City Park Golf Course Redesign, Revision I, prepared for City and County of Denver Department of Environmental Health, October 21, 2016.

to put it. As such, fill deposited at any given time may bear no physical or chemical similarity to fill deposited shortly before or long after its placement. Artificial fills can be of clean soil, contaminated soil, waste streams, inert materials or reactive materials. Artificial fill can occur in large volumes of material with relatively uniform characteristics, can vary from wagon load to wagon load, or even vary within a single truck load. Unless the artificial fill is distributed as part of an authorized placement of managed materials, fill can only be characterized after-the-fact, through soil borings. There is no generic understanding.

The VB/I-70 OU1 program as performed could only have characterized the fill materials within the area of VB/I-70 OU1 where the fill material was the ground's surface and, if then, only by analyzing the concentration of lead and arsenic. The VB/I70 OU1 remedial investigation, including investigations performed before VB/I-70 OU1 existed, largely limited characterization to the top two inches of soil and did no characterization below the top 12-inches. The remedial actions produced no additional data to provide insight into the nature of the artificial fill.

3.3.2 Hydrogeology

There is no longer a Montclair Creek and its drainage basin has been leveled almost to nonexistence by generations of placement of artificial fill. However, since the elimination of the Montclair drainage basin resulted from depositing fill atop the native alluvial sediments, the native alluvial aquifer is still present and does still convey its resource of groundwater northward toward the South Platte River. That pattern of flow, to the extent that there are data to document it, is described in the earlier section on native hydrogeology.

As was seen in the earlier discussion, the flow in the alluvial aquifer of the Montclair Creek basin still appears consistent with what one would expect were the basin still to exist. It then follows that the placement of fill atop the basin still allows infiltration of rainfall and snowmelt into the underlying alluvial sediments to maintain aquifer flow.

What cannot be demonstrated with the available data across VB/I70 OU1 is that the water quality in the alluvial aquifer is similarly unaffected by infiltration through the fill. It is not that the data show no impact. Rather, it is that there is insufficient data to discern impact to the aquifer. Since the fill has not been characterized, it is not known where one might look for significant degradation of the aquifer water. It is known that the aquifer is subject to degradation

from overlying soil contamination, because there are sites of industry releases causing such degradation.

It is known that burying wastes into the alluvial aquifer contaminates the groundwater to a degree that it cannot be discharged without treatment. Such was demonstrated by the recent construction pumping as performed at VB/I-70 OU2, where CCoD partially removed municipal waste from one of its pre-law landfills. What cannot be determined at this point, due to the almost complete lack of data, is what the impact is of precipitation leaching contaminants from the artificial fill underlying VB/I-70 OU1 and into the alluvial aquifer. There has not even been the characterization of the artificial fill to determine what the potential contaminants may be.

4. HISTORY OF VB/I-70 SUPERFUND SITE AND OU1

4.1 1997 CDPHE Sampling (*Elyria and Swansea Neighborhoods*)

The history of VB/I-70 OU1 is typically assigned a start that is closely associated with the CDPHE sampling event of residential yards east of the South Platte River in the neighborhoods of Elyria and Swansea on July 16, 1997.¹⁹ That summer, CDPHE sampled 25 residential properties in a two-block wide swath immediately north of Interstate 70, from the National Western stock yards on the west to Vasquez Boulevard on the east.²⁰ The CDPHE sampling program analyzed surface soils for arsenic, cadmium, and lead. Of the 25 residential properties tested, six had arsenic and/or lead concentrations that exceeded the removal threshold concentrations then in effect across the river in Globeville.²¹

The traditional explanation for the sampling event is that CDPHE was extending a sampling program associated with metals contamination from the ASARCO Globe Plant, as required by the 1993 Globe Consent Order. The plant, a historic smelter located west of the South Platte River, had contaminated adjacent neighborhoods on the west side of the river with air dispersal from the smelter stack and gravitational settling onto residential yards. Based upon that dispersal model, CDPHE would have been checking for the downwind limit of metals contamination east

¹⁹ USEPA R8, 1998. Sampling Analysis for Site Removal Assessment, North Denver Residential Soils, Denver, Colorado. 2.0 Site Background, p. 1.

²⁰ *Ibid.*

²¹ USEPA R8, 1998. Action Memorandum: Request for a Time-Critical Removal Action at the Vasquez Boulevard and I-70 (aka North Denver Residential Soils) Site, City and County of Denver, Colorado. A. Site Description, 1. Removal site evaluation, p. 2.

of the river. Whatever the impetus for its sampling, CDPHE responded to the results by asking USEPA R8 in November 1997 to assist with an emergency removal action.²²

4.2 1998 USEPA R8 Phase I Sampling (North Denver Residential Soils Site)

1998 was a pivotal year leading toward VB/I-70 OU1. In response to the CDPHE request, USEPA R8 mobilized an Emergency Response team with an On-Scene Coordinator for the North Denver Residential Soils project.²³ As its emergency response, USEPA R8 undertook a spatially extensive Phase I screening-level sampling program to identify properties that were potential candidates for time-critical removal in the North Denver Residential Soils area. East of the river, the Phase I area went from the river on the west to Colorado and Vasquez Boulevards on the east and from 38th to 56th Avenues on the south and north, respectively.²⁴ As Phase I was being implemented, CDPHE requested USEPA R8 to add the southwest corner of Globeville to the project. This was the only portion of Globeville not yet investigated.

The boundaries for Phase I were considered “arbitrary since little was known about a possible source of the arsenic and lead being investigated.”²⁵ The lack of reference to the ASARCO Globe Plant investigation creates ambiguity on the traditional motivation for the 1997 CDPHE sampling that started these investigations.

Phase I sampling occurred in March and April 1998 and the preliminary results were summarized in July 1998.²⁶ Individual residential properties were typically sampled three times. Two surface samples (0 to 2 inches deep) were collected, one each from the front and back yard, and one “depth” sample (6 to 10 inches deep). The depth sample might be from either the front or the back yard.

Phase I sampled 1,152 properties with 2,363 surface samples and 1,096 depth samples. The analyses were done using x-ray fluorescence (XFR) to measure concentrations of arsenic and

²² CDPHE, 1997, Request for Emergency Removal Action, Elyria Neighborhood, Denver, CO. Letter from Howard Roitman, Colorado Department of Public Health and Environment, to Steve Hawthorn, EPA Region VIII. November 4, 1997.

²³ USEPA R8, 2003 submittal of Information Package for the EPA National Remedy Review Board, p. 4.

²⁴ *Ibid.*

²⁵ *Ibid.*

²⁶ USEPA R8, 1998. Sampling Analysis for Site Removal Assessment, North Denver Residential Soils, Denver, Colorado. 7.0 Summary, p. 10.

lead.²⁷ A total of 46 (4.2% of all tested) properties assessed in Phase I exceeded the Globe Plant Site thresholds for acute exposure for arsenic and/or lead. Analyses from an additional 248 (22.6% of all tested) properties reported arsenic and/or lead concentrations between the Globe Site thresholds for chronic and acute exposures.²⁸

4.3 1998 USEPA R8 Phase II Sampling (North Denver Residential Soils Site and Vasquez Boulevard and I-70 Site)

Based upon the results of the Phase I sampling, a Phase II sampling program was developed to identify the properties that needed time-critical removal action. The Phase II sampling included the areas sampled in Phase I and added the area between the South Platte River and Colorado Boulevard from 38th Avenue to 35th Avenue.²⁹ Also as a result of the Phase I sampling, USEPA R8 issued an Action Memorandum requesting approval for a Time-Critical Removal Action.³⁰ Finally, during Phase II the term Vasquez Boulevard and I-70 Site began to replace the term North Denver Residential Soils.

Phase II sampling was performed in July and August 1998. Phase II sampling protocols differed from those of Phase I. Phase II sampling was performed only on surface samples, *i.e.*, the top two inches. Surface samples were taken from front yards and from back yards, as before, but for Phase II, 5 samples were collected and composited into a single sample for analysis.³¹ By doing so, serendipitous sampling of hot spot(s) would not qualify a property for removal action unless the 5-spot composite (average) exceeded the threshold for the time-critical removal action. If either the front yard or back yard composited average exceeded the threshold, the property qualified for soil removal and replacement.

The Phase II sampling was performed on properties where the Phase I sampling results indicated a potential need for emergency removal, but only for those properties where the threshold

²⁷ Cadmium was also analyzed, but the XRF results were deemed unreliable and cadmium was dropped from the analyte list. USEPA R8, 1998. Sampling Analysis for Site Removal Assessment, North Denver Residential Soils, Denver, Colorado. 6.0 Sample Results, p. 8.

²⁸ USEPA R8, 1998. Sampling Analysis for Site Removal Assessment, North Denver Residential Soils, Denver, Colorado. 6.0 Sample Results, Table 3.

²⁹ USEPA R8, 1998. Sampling Analysis for Site Removal Assessment, North Denver Residential Soils, Denver, Colorado. 7.0 Summary, p. 10.

³⁰ USEPA R8, 1998. Action Memorandum: Request for a Time-Critical Removal Action at the Vasquez Boulevard and I-70 (aka North Denver Residential Soils) Site, City and County of Denver, Colorado. September 16, 1998.

³¹ USEPA R8, 2003 submittal of Information Package for the EPA National Remedy Review Board, p. 5.

concentrations were exceeded in the surface samples. If the depth sample exceeded a threshold, but the corresponding surface sample did not, Phase II sampling, assessment, and remove and replace under the time-critical emergency program did not occur.

The expanded territory to the south, between 38th Avenue and 35th Avenue was sampled with Phase I protocol and, had any surface samples there showed potential acute danger, they would have been resampled for average – not spot – concentrations before being designated a target for time-critical removal. The expanded area raised the total count of properties assessed with the Phase I protocol, 1,096, to a total of 1,393. The distribution of concentrations for arsenic and lead reported for the combined population and, based upon those distributions, no new candidates for time-critical removal were identified in the added area.³²

Of the 46 properties with Phase I concentrations exceeding the thresholds, seven of them (15.2%) had the exceedances in the depth (6 to 10 inches), not surface, sample. These properties were not further sampled for time-critical removal using the Phase II sampling protocol.³³ Of the 37 properties with surface samples exceeding the thresholds in Phase I grab samples and sampled in the Phase II program, only 21 properties (56.8%) exceeded the Phase II compositing (averaging) threshold. Of these 21 properties, time-critical removal was complete on 18.³⁴

4.4 1999 USEPA R8 Detailed Investigative Studies (*Vasquez Boulevard and I-70 Site*)

In January 1999, based upon the arsenic and lead concentration data documented with Phase I and Phase II sampling that demonstrated widespread risk of chronic exposure, USEPA R8 proposed listing the Vasquez Boulevard and I-70 Site on the National Priority List. The proposal to create a Vasquez Boulevard and I-70 Superfund Site included three defined operable units. Operable Unit 1 was narrowly defined to include “residential yards within the study area with levels of lead or arsenic in soil that present an unacceptable risk to human health.”³⁵ The study area was the area characterized by Phases I and II with an additional southward shift of the

³² USEPA R8, 2003. Information Package for the EPA National Remedy Review Board, Test pp. 5 and 6, FIGURES, Table 3.

³³ USEPA R8, 1998. Action Memorandum: Request for a Time-Critical Removal Action at the Vasquez Boulevard and I-70 (aka North Denver Residential Soils) Site, City and County of Denver, Colorado. A. Site Description, 1. Removal site evaluation, p. 2.

³⁴ USEPA R8, 2003. Information Package for the EPA National Remedy Review Board, p. 6.

³⁵ USEPA R8, 2003. Submittal of Information Package for the EPA National Remedy Review Board, p. 7.

southern boundary to Martin Luther King Boulevard. Concurrent with the NPL proposal, the emergency removal was being implemented.

While the NPL listing was being contemplated, USEPA undertook the design and implementation of two investigations and preparation for a third round of sampling; ~~the~~ the Physico-Chemical Characterization of Soils, the Residential Risk-Based Sampling, and a Phase III investigation.

The Physico-Chemical Characterization was an investigation of some of the surface soil samples collected during the Phase I investigation. None of the depth samples were investigated. Of the approximately 2400 surface samples, 120 were used.^{36 37} The 120 characterization samples were sieved to isolate the particle-size fraction below 2 mm (very coarse sand and below), deemed *bulk* sample, and that below 0.25 mm (fine sand, silt, and clay), deemed *fine* sample. The concentrations of arsenic, cadmium, lead, and zinc were each comparable between the fine and bulk samples. In spite of this overall parity in composition, most of the arsenic and, to a degree lead, in the fine soil fractions is seen in the smaller end of the fine fraction, between 0.05 and 0.005 mm (silt).

Twenty percent of the samples (n=24) had laboratory analyses run of each metal for comparison with new XRF analyses.³⁸ This comparison showed XRF analyses were consistently about 30% higher than lab analyses. Twenty-two of the fine samples were analyzed to identify the mineral species containing lead and those containing arsenic. Arsenic was present dominantly as As₂O₃ with noticeable concentrations of AsSbO and organic arsenic. Lead was present dominantly as PbAsO with significant concentrations of PbMnO and lead phosphate.³⁹ Finally, 10 samples were tested for *in vitro* bioassessability [BAC] for lead and arsenic, hypothetically a measure of the respective metals' solubility under laboratory testing meant to imitate gastric conditions.

³⁶ USEPA R8, 2001. Final Remedial Investigation, Part 3.1. pp. 3-1 to 3.4.

³⁷ The basis for this selection is not reported in the Final Remedial Investigation.

³⁸ The basis for this selection is not reported in the Final Remedial Investigation.

³⁹ Curiously, even though PbAsO dominated the speciation of lead, PbAsO was minimally present in the arsenic speciation. This may in part be due to nomenclature; metal metal oxides, as in AsSbO and PbAsO do not represent a single mineral phase, as for instance arsenic trioxide (As₂O₃) does. Rather, they are a convenient shorthand representing a range of minerals with variable compositions comprised of oxygen and the attendant metals.

USEPA R8 notes, “[A]ll *in vitro* BAC results (especially those for arsenic) must be interpreted and used with caution.”⁴⁰

The Residential Risk-Based Sampling Investigation sought to assess three objectives. The first is performing high-density (“intensive”) sampling of surface soils to characterize the nature and extent of the four metals within selected residential yards. The second is quantifying the concentration of some or all of the four metals in various residential media at residences identified for emergency removal action. The third is estimating via biomonitoring the pre-removal exposure levels of residents at properties scheduled for emergency removal actions.⁴¹

The high-density sampling of surface soils was performed in 1998 on a total of eight properties, five that were impacted and three that were not. The impacted properties were the five properties with the highest arsenic concentrations among the 18 properties which underwent emergency remove-and-replace as a result of the Phase I and Phase II sampling.⁴² The unimpacted properties were selected from those with all arsenic concentrations below the removal action level of 450 ppm.⁴³ Two consulting firms were used, one sampled the impacted properties and the second, the unimpacted.

Two sets of samples were collected. Surface soils (0” to 2”) were collected on a 5’ by 5’ grid over the entire yards, with the grid potentially extending across property lines onto adjacent properties. In addition, at selected locations, cores were taken to allow analyses of vertical profiles of concentrations over the top 12 inches of soil, with samples from 2”-4”, 4”-6”, 6”-8”, 8”-10”, and 10” to 12”.⁴⁴ Nothing below 12” was sampled. A total of 36 profiles were measured among the eight properties. At least two 12-inch profiles were sampled on each property and as many as 9 profiles at a single property were sampled.

The high-density sampling of the five impacted and three unimpacted properties influenced the development of the VB&I-70 OU1 in two important ways. First, the spatial distributions seen among the surface samples were used to establish the sampling densities and protocols to be used

⁴⁰ USEPA R8, 2001. Final Remedial Investigation, Part 3.1. pp. 3-4.

⁴¹ USEPA R8, 2001. Final Remedial Investigation, Part 3.2. pp. 3-4 to 3-18.

⁴² USEPA R8, 2001. Final Remedial Investigation, Part 3.2.1 p. 3-5.

⁴³ USEPA R8, 2001. Final Remedial Investigation, Part 3.2.1 p. 3-6.

⁴⁴ USEPA R8, 2001. Final Remedial Investigation, Part 3.2.1 p. 3-6.

by a Phase III sampling program then in the design stage.⁴⁵ Second, the results of the detailed vertical profiles were used to justify limiting future sampling to the top two inches of soil in residential soils, and to rationalize the remove-and-replace remedial action to a depth of only 12 inches. In point of fact, the detailed vertical sampling of impacted properties was performed only on properties previously known to have higher concentrations at the surface than at depth.

The high-density sampling of the surface soil (0" to 2" in depth on a 5-foot grid) in the individual yards showed similar patterns to the spatial distribution seen among yards during the Phase I sampling, *i.e.*, concentrations appeared random in nature and were seemingly unaffected by neighboring concentrations, even at the small scale. The distributions of contaminants at a property were neither normally nor log-normally distributed. As a result, statistical normality for purposes of establishing risk-based decisions would need be developed by compositing sufficiently high numbers of samples to generate a pseudo-normal distribution.⁴⁶

4.5 1999 USEPA R8 Phase III Sampling (*Vasquez Boulevard/I-70 Site*)

Because of the great area involved, the insufficiency of the Phase I and Phase II programs as a basis for remedial decisions, and a lack of spatial patterns of arsenic contamination requiring sampling of virtually every property, the Agency decided to implement the additional characterization effort, Phase III sampling. The stated objectives for Phase III were 1) to collect sufficient data to support a quantitative baseline human health risk assessment, and 2) collect sufficient data to define the nature and extent of contamination.

The Phase III sampling program was set before the North Denver Residential Soils (VB/I-70) Site was NPL-listed in July 1999. Notwithstanding the timing, USEPA R8 considered the Phase III Program to be the VB/I-70 Superfund Site OU1 Remedial Investigation.⁴⁷ The design of the Phase III program precludes defining the nature and extent of contamination. Even with respect to lead and arsenic, Phase III defines the extent of the contamination only in the top 2 inches of soil, and then only the extent in the yards of residences, schools, and parks.

⁴⁵ USEPA R8, 2001. Final Remedial Investigation, Part 3.2.1 pp. 3-21 to 3-22.

⁴⁶ USEPA R8, 2001. Final Remedial Investigation, Part 3.2.1 pp. 3-21 to 3-26.

⁴⁷ USEPA R8, 2003. Information Package for the EPA National Remedy Review Board, p. 10.

A Remedial Investigation [RI] of an area “... disproportionately affected by environmental impacts from many sources...”⁴⁸ that is limited to two metals from only the top two inches of soil of only residential properties is inherently inappropriate and cannot be protective of human health and the environment. A Feasibility Study [FS] of the results of such investigations can be no more appropriate or protective than the RI. A baseline Human Health Risk Assessment [HHRA] of potential remediation choices identified in the flawed RI/FS assesses only the risk of a world that does not exist, and it, too, is neither appropriate nor protective. A Record of Decision [ROD] that neatly ties up an RI, an FS and an HHRA that are each inappropriate and non-protective of human health and the environment can not, by virtue of being consistent, create appropriateness or protectiveness in the Remedial Action (RA). As is discussed in more detail below, implementing the flawed RAs does not mark the successful implementation of the Superfund program at the Site, and it does not justify the deletion of VB/I-70 OU1 from it.

5. TWENTY YEARS OF FAILURE AT VB/I-70 OU1

5.1 *VB/I-70 OU1 and Environmental Justice*

All communities are equal, but some communities are more equal than others.⁴⁹

USEPA R8 designated VB/I-70 OU1 an Environmental Justice Site

... because the residents are predominantly low income and minority. It is also disproportionately affected by environmental impacts from many sources including industry, other Superfund sites, and major transportation corridors.⁵⁰

Scoring a site for NPL listing does not require the site be completely evaluated; a partial site assessment that generates a threshold score for listing is sufficient. Once listed, a complete assessment is done. This was the sequence begun for VB/I-70 OU1. CDPHE identified in 1997 dangerously high levels of arsenic and lead in residential soils. Subsequent investigations, also of lead and arsenic and also only in residential, school, and park soils, indicated a substantial area at risk for acute and chronic exposure. The investigated soils surpassed the listing threshold

⁴⁸ This is the characterization of VB/I-70 OU1 in the 2003 Record of Decision, as an Environmental Justice Site.

⁴⁹ With apologies to George Orwell, 1945, *Animal Farm*.

⁵⁰ USEPA R8, 2003. Record of Decision, Vasquez Boulevard/Interstate 70 Superfund Site, Operable Unit 1 Residential Soils. 1.0 Decision Summary, p. 1.

upon consideration only of lead and arsenic contamination that was found in shallow soils at residences.

Once listed, it would have been appropriate and protective of human health and the environment for USEPA R8 to have evaluated the area for other contaminants, in other media, potentially from other sources including the “industry, other Superfund sites, and major transportation corridors” recognized in the Environmental Justice designation. That is what should have been done.

For reason or reasons not yet disclosed, USEPA R8 did no investigation beyond the two contaminants, the single medium, and the presumed source that generated the threshold score for listing. Not to have done so, in spite of acknowledging disproportionate impacts to the community and environment from many sources, is inappropriate and non-protective. The inappropriate and non-protective response by USEPA R8 does nothing to assuage the burden of environmental injustice on this community. It underscores and perpetuates that injustice.

5.2 *The Conceptual Model for VB/I-70 OU1*

The initial conceptual model for VB/I-70, the mental construct to guide the initial site characterization, was adopted wholesale from the ASARCO Globe Plant site west of the South Platte River. That conceptual model held that metal contamination of residential soils resulted from air-fall of dust from the exhaust stacks of smelters onto the yards, wind deposition of dust from solid wastes at smelter sites, and/or surface application of lawn-care products.⁵¹ The data at and adjacent to the Globe Plant supported that conceptual model there. A critical and common element of this conceptual model was that all metal contamination was deposited on the surface of the ground.

An initial conceptual model is a first technical guess of what may be going on at a site. It guides the initial investigation. When characterization data are collected, the initial conceptual model should be tested against that data, and the conceptual model modified as dictated by the data. This is an iterative process that is repeated until the conceptual model and the characterization data tell the same story. When, and only when, the investigative data and the conceptual model

⁵¹ USEPA R8, 2001. Remedial Investigation VB/I-70 OU1, Figure 5-1.

match, it is appropriate and protective of human health and the environment to proceed with the HHRA and FS portions of the Superfund process to identify one or more RAs.⁵²

5.2.1 Dust Dispersal and Air-Fall Deposition

As the investigation of the area to become VB/I-70 OU1 proceeded, it became increasingly evident that the investigative data collected east of the river was inconsistent with the source postulated in the initial conceptual model. In September, 1998, USEPA R8 still accepted the possibility that air-fall was a viable mechanism in the North Denver Residential Soils Site, “These hazardous substances may have been released into the residential through the Community by aerial deposition.”⁵³ That position further softened with time. “At the time of the NPL listing proposal, EPA had little information about the possible source or sources of lead or arsenic in soil.”⁵⁴ By September 1999, after VB/I-70 OU1 had been listed, it was in question whether smelters were the source, and, if so, it could be either “atmospheric deposition of smelter emissions or importation of fill material from locations contaminated with smelter waste.”⁵⁵ [Emphases added.]

Before the Superfund listing proposal and the RI (*i.e.*, Phase III), the unexpected information from the data on contaminant distribution was considered a major discovery. One of the “striking findings” of the Phase I and Phase II sampling programs was that

properties with elevated levels of arsenic occur at widely scattered locations across the site with no clear spatial pattern. Properties with elevated levels of arsenic were located immediately adjacent to one or more properties that were apparently not affected. A gradient of arsenic concentrations, not random concentrations, would be expected if the source of arsenic contamination was emissions from a point source such as a smelter.⁵⁶

The significance of the findings from the earlier investigations of lead and arsenic on risks for the residents in North Denver, unfortunately, did not register sufficiently to create a change in the conceptual model or in the trajectory of the Superfund program at VB/I-70 OU1. USEPA R8 acknowledged in its RI that the source of the contaminants was “not known,” but still speculated

⁵² USEPA R8, 2018. Oral tutorial from USEPA R8 staff to VB/I-70 CAG at CAG meeting held April 17, 2018, Denver, Colorado.

⁵³ USEPA R8, 1998. Action Memorandum, p. 3.

⁵⁴ USEPA R8, 2003. Submittal of Information Package for the EPA National Remedy Review Board, p. 6.

⁵⁵ USEPA R8, 1999. Project Plan Pilot-Scale Soil Characterization Study, p. 1–2.

⁵⁶ USEPA R8, 2003. Information Package for the EPA National Remedy Review Board, p. 6.

that the contamination “may” be attributable to the lawn-care productions or smelter dust of the conceptual model.⁵⁷ USEPA R8 further acknowledged that the pattern of distribution, unlike west of the river, did not fit the air-fall distribution pattern.⁵⁸

Subsequent to the RI, FS, and HHRA, but six months prior to the ROD, USEPA R8 opened up the potential sources for the arsenic and lead across VB/I-70 OU1 beyond the Conceptual Model. In the memorandum to request the non-time-critical removal action due to chronic-exposure risks, the discussion of sources says the sources are not air-fall from the Globe Plant but alternative sources may be air-fall from the Omaha & Grant Smelter, placement of fill materials from locations contaminated by wastes from any of the smelter sites, and lawn care products.⁵⁹ Within the ROD, the sources are listed as “... likely a combination of historic smelter smokestack emissions, lawn care products, and other industrial sources.”⁶⁰

5.2.2 Lawn-Care Product (PAX) Usage

What USEPA R8 did not do, what would have been appropriate and protective of public health and the environment, is revisit the conceptual model and identify the sources and the distribution and exposure mechanisms that were consistent with the data collected. Had USEPA R8 done so, there would be no need to discuss air-fall and certainly no need to persist in proposing the crab-grass herbicide PAX as a possible culprit for the contamination.

In June 1998, ASARCO asserted its position that the procedures being used to characterize the lead and arsenic distribution was requiring ASARCO “to address areas that exceed the action levels for arsenic and lead that are not due to the Globe Plant.”⁶¹ ASARCO’s position was not inconsistent with USEPA R8’s assessment at that time; little was known about a possible source of the metals being investigated, and what was known did not support air-fall of ASARCO stack dust.

ASARCO went further. Based upon work by ASARCO consultants, ASARCO postulated that an alternative source for arsenic was the herbicide PAX, used through at least the 1960s for crab-

⁵⁷ USEPA R8, 2001. Remedial Investigation VB/I-70 OU1. 1.0 Site Background, p. 1-2.

⁵⁸ USEPA R8, 2001. Remedial Investigation VB/I-70 OU1. 4.0 Nature and Extent of Contamination, pp. 4-6, 4-8.

⁵⁹ USEPA R8, 2003. Action Memorandum: Request for Non-Time Critical Removal Action, VB/I-70 ... NPL Site, Denver Colorado. p. 3.

⁶⁰ USEPA R8, 2003. Record of Decision VB/I-70 OU1. 1.0 Decision Summary, p. 10.

⁶¹ USEPA R8, 2003. Information Package for the EPA National Remedy Review Board, uncited quote on p. 3.

grass control commercially and residentially.⁶² This particular speculative source for the arsenic was effectively debunked in Globeville and, by extension, east of the river by the assessment of John Drexler for CDPHE.⁶³ Based upon USEPA R8's research into the PAX issue, it concluded its research was "helpful" but "inconclusive."⁶⁴ It is disheartening to see USEPA R8 persist in bringing up this red herring in both its Notice of Intent to partially delete and at its recently held public meeting,⁶⁵ it is inappropriate and distracts from the important issues that could address the protection of human health and the environment.

5.3 *An Alternative Conceptual Model for VB/I-70 OU1*

The Phase I, Phase II, and Phase III sampling programs individually and collectively fail to support the air-fall distribution of smelter wastes as the source of the arsenic and lead contamination in the top 12 inches of residential soils. Rather, the data both site-wide and within individual properties appears to be random, a finding deemed "striking" by USEPA R8.⁶⁶

Upon discovering that the air dispersal and settling model was not consistent with the distribution of arsenic and lead across VB/I70 OU1, it would have been appropriate and protective of human health and the environment for USEPA R8 to have developed an alternative conceptual model for the distribution and extent of the lead and arsenic contamination. The objective would have been a conceptual model that is consistent laterally and vertically with the characterization data, the history of the neighborhoods, and data from other investigations in the area.

History tells us that much of the VB/I-70 OU1 area was subject to the placement of fill over a period of decades. The fill was brought into the area to lift the land elevation in the Montclair Creek basin to the grade of the railroad lines built across that basin. That gradual history of filling is consistent with localized areas of contamination, seemingly unrelated to uncontaminated soils adjacent to them. One load of fill may have had high contaminant concentration; the next one, maybe not. If a house was built on a property with contaminated

⁶² ASARCO, 1998. Evaluation of Extent of Impacts to Soils Due to Historical Air Emissions From the ASARCO, Inc. Globe Plant. Prepared by EnviroGroup for ASARCO, Inc. April 7, 1998.

⁶³ CDPHE, 1998, A Study on the Source of Anomalous Arsenic Concentrations in Soils from the Globeville Community – Denver, Colorado.

⁶⁴ USEPA R8, 2003. Record of Decision VB/I-70 OU1. 1.0 Decision Summary, p. 6.

⁶⁵ USEPA R8, 2019. Quarterly Public Information Meeting, VB/I-70 Site, March 12, 2019, Denver CO.

⁶⁶ USEPA R8, 2003 submittal of Information Package for the EPA National Remedy Review Board, p. 6.

fill, the property may have a residential soil contamination problem. If a house was built on loads of fill soil without contaminants, the residential soils would be without a contamination problem. The site history of fill placement is consistent with the random nature of the VB/I-70 characterization data.

Data from other investigative programs in the VB/I-70 OU1 area demonstrate that fill in the area does contain wastes that are typically contaminated with lead and arsenic, wastes such as smelter slag or tannery wastes. From 1992 through 1998, CDOT multiply characterized the soils in the vicinity of the Brighton Boulevard interchange with I-70 in preparation for redesigning the structure.⁶⁷ The borings collected for the CDOT investigations recovered such wastes and analyses of some showed high concentrations of lead and arsenic. The results from these investigations were provided to both USEPA R8 and CDPHE prior to or during the North Denver Residential Soils project.

The most recent CDOT investigations occurred approximately coincident with the 1998 CDPHE sampling that tripped the request by CDPHE for USEPA R8 assistance with the time-critical removal action. CDPHE analyzed the surface soils for the same constituents as CDOT and the west end of that CDPHE sampling program overlapped with the CDOT investigative area. An early discussion summarizing the CDPHE program made no reference to any relationship between the CDPHE sampling and the Globe Plant investigations west of the river.⁶⁸ Perhaps the purpose for the CDPHE investigation into Elyria and Swansea was to investigate concerns about CDOT-documented fill in the neighborhood soils, as opposed to stack discharges from Globe drifting into the neighborhoods.

The Environmental Justice designation alludes to contaminants beyond lead and arsenic as neighborhood burdens. The CDOT investigations in the vicinity of the Brighton Boulevard interchange with I-70 document contaminants other than just arsenic and lead in the fill that they penetrated.⁶⁹ The fill-model would predict that fill containing constituents other than arsenic and lead could generate acute or chronic levels of surface contamination of those constituents. Since

⁶⁷ CDOT 1998. Final Site Investigation, I-70 Phase II and III Construction, 11th Street to Brighton Boulevard, City and County of Denver, Colorado. Conclusions and Recommendations, pp. 39-47.

⁶⁸ USEPA R8, 1998. Sampling Analysis for Site Removal Assessment, North Denver Residential Soils, Denver, Colorado. 1.0 Sample Results, p. 1.

⁶⁹ CDOT, 1998. Materials Management Plan, I-70 Phase II and III Construction, I-70 Modifications Humboldt/44th to Brighton Boulevard, Denver, Colorado. 3.0 Site Environmental Conditions, p. 5.

the VB/I-70 OU1 investigation did not look for such contaminants, their distribution and extent is unknown. Additional remedial investigation across VB/I-70 OU1 for other contaminants known to exist in fill under VB/I-70 OU1 would test this prediction. Performing such investigation is appropriate and protective of human health and the environment.

For the fill-model to be consistent with the VB/I-70 OU1 data, it must account for contaminants, *e.g.*, arsenic and lead, in the top 12 inches of residential soils. At a minimum, if the contaminated fill material extends to the surface of the ground, the fill-model is consistent with the Site data. But it is not necessary that the contaminated fill have been placed within 12 inches of the ground's surface for contaminants from the fill to have been introduced to the top 12 inches of soil. It is only necessary that there be some mechanism(s) that moved a contaminant from the underlying source fill into the soils where it was found by the North Denver Residential Soils and VB/I70 OU1 programs. Such mechanisms abound.

Upward subsurface transport processes can be physical and/or chemical. The simplest physical process is diffusion and it is particularly effective when the migrating contaminant is a gas. Volatile organic carbon compounds in contaminated fill can vaporize in the vadose zone and migrate to the surface or into basements as gas. Radon, a gaseous decay product from uranium mill tailings, is another example.

Arid and semiarid climates are known for the upward transport of dissolved minerals by capillary action, or wicking, of unsaturated-zone (vadose) water. At or near the surface, the water evaporates and the dissolved solids precipitate as soil minerals. When the pore water at depth contains arsenic and lead from dissolution of those metals from contaminated fill, those metals are carried upward with the water and, upon evaporation of the soil water, form mineral grains in the shallow or surface soil that contain arsenic and lead. Carried to the extreme, this is one of the mechanisms of formation of caliche, hardpan, gypcrust, or even nitrate salts ore deposits.

Upward subsurface transport processes can be botanical. Plants roots systems typically draw water from the vadose zone, the zone of water-bearing soil or rock above the water table. The plant picks up not only the water, but the dissolved metals in the water. The plant transpires the water and the metals are either incorporated into the plant (primarily in leaves, but also in twigs, branches, roots, bark, etc.) or are excreted onto leaves or as organic aerosols. These metals are returned to the soil to form mineral grains at the surface of the soil when the plant debris decays.

(The plant-uptake mechanism is so efficient that phytoremediation is used at some sites to remediate soil or soil water contamination by harvesting annual plant debris and disposing of it as contaminated waste, so that it doesn't recycle back into the soil.)

Upward subsurface transport processes can be zoological. A host of animals live in and burrow through soils and bring subsurface materials to the surface as part of their life cycle. Snakes, voles and moles are attention-getting. Less obvious, but far more important for upward mobility of contaminants, are invertebrates. Ants and earthworms are prodigious movers of subsurface soil, the former by colony construction and the latter way of their gut. Ant hills and worm casting represent an astonishingly high volume of earth turning that is almost invisible unless one looks for it.

Upward subsurface transport processes can be anthropogenic. CDOT investigates the fill below VB/I-70 OU1 not out of scientific curiosity but because it intends to dig up that fill – with its attendant contaminants – and CDOT wants to know how to manage it. When a storm sewer or drainage channel is excavated and the route is through contaminated soil, contamination may be brought to the surface. The installation of a water line or a sewer line may bring contaminated soil to the surface of a residential yard. The excavation of a basement may bring contaminants in the fill to the shallow yard soils, whereas construction on a slab does not. (I believe there are public comments being submitted as to the tragic impact this mechanism had on one family in VB/I-70 OU1.)

The mechanisms by which contaminants are brought from depth to the surface of the ground or the shallow subsurface create complexities for site characterization. These mechanisms move the contaminants upward, something that is not intuitively obvious. They can create contaminant concentrations that are higher at the surface than existed in the in-depth source. The form of the contaminant may be more dangerous than that at the source. An example from VB/I-70 OU1 may be arsenic. The more soluble and less toxic form of arsenic is As^{+5} , pentavalent arsenic and arsenic species more likely dissolved in vadose water. The arsenic found at dangerous concentrations in shallow soils at VB/I-70 OU1 is As^{+3} , trivalent arsenic in the mineral form arsenic trioxide, the less soluble and more toxic form of arsenic. Similarly, a load of fill contaminated with the chlorinated solvent TCE from a meat packing plant (used as a degreaser) may have aged to more toxic daughter products by the time it is found in the shallow soils.

6.0 SUMMARY

6.1 *The Fantasy*

USEPA Region 8 asserts, in its Notice of Intent to Delete VB/I-70 OU1, “The Site was placed on the NPL in 1999 due to metal contamination associated with historical smelter operations.”⁷⁰ In 1997 or early 1998, this assertion may have been believed factual. By the time the Site was placed on the NPL list, that was not the case. USEPA R8’s description to USEPA’s National Remedy Review Board at the time of the ROD stated, “At the time of the NPL listing proposal, EPA had little information about the possible source or sources of lead or arsenic in soil.”⁷¹ Shortly after listing, an assessment stated the source was unknown and that, if smelter waste were a source, it could possibly be as air-fall of stack dust or as importation of contaminated fill.⁷²

USEPA Region 8 further asserts, in its Notice of Intent to Delete VB/I-70 OU1, “Subsequent investigations revealed that arsenic contamination might also be present as a result of application of lawn care products.”⁷³ The suggestion of lawn care product contribution was floated by the lead PRP – a smelter operator – to cloud responsibility. The suggestion was convincingly debunked long ago.

Region 8’s proffering of these assertions is disingenuous at best. It is the rote repetition of an assumption and of a speculation that each predate any investigations at the Site and that both have been established by investigations not to be valid. It is also illustrative of the fatally inappropriate and inadequate assessment and remediation of VB/I-70 OU1 that has controlled activity here since the RI and that still prevents the identification of investigative and remedial actions that would demonstrably be protective of human health and of the environment.

6.2 *The Reality*

USEPA R8 activities in response to the 1997 CDPHE findings in Elyria and Swansea, *i.e.*, Phases I, Phase II and the time-critical removal action, were appropriate, timely, and protective

⁷⁰ Federal Register, Vol. 84, No. 25, IV. Basis for Intended Partial Site Deletion, Site Background and History, p. 2118.

⁷¹ USEPA R8, 2003. Information Package for the EPA National Remedy Review Board, p. 6.

⁷² USEPA R8, 1999. Project Plan Pilot-Scale Soil Characterization Study, p. 1–2.

⁷³ Federal Register, Vol. 84, No. 25, IV. Basis for Intended Partial Site Deletion, Site Background and History, p. 2118.

of human health and safety. Something had to be done to mitigate acutely dangerous concentrations of lead and arsenic identified in the grab sampling of the top two inches of soils at residences across the study area. A time-critical removal action need not be concerned with how or when the arsenic and lead got there; the objective is to mitigate the immediate danger.

By the time the VB/I-70 OU1 RI (Phase III) started, it was known, and acknowledged, that the conceptual model of metal contamination associated with air-fall of dust from one or more smelter stacks was refuted by the data collected. The suggestion that the metals contamination might be “a result of application of lawn care products” was effectively debunked. Why, then, does USEPA R8 resurrect these two tropes in its Notice of Intent to Delete VB/I-70 OU1? Because it must do so.

It is the only way to justify the use of the emergency response remedy (remove-and-replace the top 12 inches of soil) as the appropriate and protective non-time critical removal remedy for chronic exposure scattered across VB/I-70 OU1. The emergency remedy can be rationalized as complete, adequate, appropriate, protective of human health and the environment, and permanent for chronic exposure if, and only if, the only contaminants are arsenic and lead, all of the contaminants were applied at or fell on the surface of the ground, and the depth of the contamination does not extend below a foot. Site data documented none of these constraints and documented that most do not to exist.

The original investigation establishing dangerously high arsenic and lead concentrations on the east side of the South Platte River is commonly attributed to a program of mapping sky-fall contaminants of stack emissions mapped to occur around a smelter on the west side of the river. When that initial investigation found common contaminants east of the river, the assumption (perhaps appropriate as a starting point) was that the distribution mechanism was sky-fall and the historic source of the contamination was smelter stack(s).

The investigations supporting the time-critical removal action (12-inch removal and replacement of residential soils) established the sky-fall assumption and the smelter-stack as source assumptions were invalid. Notwithstanding that, the VB/I-70 RI (Phase III sampling) accepted the sky-fall assumption and the smelter-stack-as-source assumption as the conceptual model for use. Locked into the constraints of the original sky-fall/stack conceptual model, the VB/I-70 OU1 results were predetermined. It inevitably produced a remedy consistent with, but limited

by, those assumptions. That is, the only contaminants of concern were the stack metals arsenic and lead. Sky-fall to the ground (or herbicide spread on the ground) meant surficial soil was the only medium impacted. Why the initial conceptual model was never adapted to the early Site data is not documented. But the transference of the emergency remedy to be the remedy for chronic exposure was the inevitable result.

The time-critical remedy is not adequate, it is not appropriate, it is not protective of human health or the environment, and it is not complete for the chronic exposure situation. The time-critical remedy fails at four levels. Too few contaminants have been assessed for impacts in the neighborhoods overlying the Montclair Creek drainage basin. The VB/I-70 OU1 program erred in representing that testing of the top 2 inches of soil would adequately detect all contamination properly of concern. The top 12 inches of soil is not the sole impacted medium. The VB/I-70 OU1 program did not adequately consider or implement the then-new concept of "protecting the remedy."

6.2.1 Alternative and Additional Waste Sources

The remedy is not adequate or appropriate because it does not consider contaminants other than lead and arsenic from smelter wastes. Once the analytical data from the VB/I-70 OU1 program established that sky-fall was not the distribution mechanism, the dangers from arsenic and lead contamination in the neighborhoods became disassociated with smelter stacks as the source. The data established that the distribution of the high arsenic and lead contamination was more consistent with random placement, such as might be expected with random fill of the low-lying area through the decades with loads of varying contaminants and contaminant concentrations.

As such, there are many potential sources of the lead and arsenic documented in the neighborhoods. Certainly, smelters produce wastes high in arsenic and lead, including stack emissions and slag. But, so do mine spoil, off-spec ores rejected for smelting, coal combustion wastes, tanneries and industrial manufacturing of lead and arsenic containing products. Any and all of these have contaminated sites elsewhere in Denver. Each is a potential source for some of the VB/I-70 OU1 arsenic and lead contamination.

The CDOT investigations discussed earlier document contaminants in the fill of the Montclair Creek basin other than arsenic and lead and sources of lead and arsenic other than smelter

wastes. Once the random distribution of lead and arsenic was established, negating smelter stacks as the source of the metals, it would have been appropriate and protection for the VB/I-70 OU1 program to have been expanded, assessing other contaminants that may also have been introduced to the yards of the neighborhoods by decades of filling.

Just as variations in lead and arsenic among loads of fill burden the residential soils of the neighborhoods, so might variations in PAHs, PCBs, chlorinated solvents, coal gasification tars, or uranium mill tailings (as examples) among loads of fill. Unless contamination by these substances happened to coincident with severe arsenic and contamination, these contaminants would remain in the top 12 inches of the soil of residential yards that were unaddressed by the remedy of VB/I-70 OU1.

6.2.2 Concentration versus Depth

USEPA R8 puts great emphasis on the concept that the highest concentrations of arsenic and lead occur at the surface of the land and that concentrations decline rapidly with increasing depth. This perception is fundamental to arguments that the VB/I-70 OU1 remedy is adequate, appropriate, protective, and complete. It is a perception that has become greatly over pitched⁷⁴ and that is minimally, if at all, supported by Site arsenic and lead data.

All investigative data in the VB/I-70 OU1 area is shallow soil data. No North Denver Residential Soils or VB/I-70 OU1 Site investigations for any contaminant have been reported for any depth greater than 12 inches. It is therefore impossible to assert validly that any part of the soil below 12 inches has lower concentration that that within the top 12 inches, let alone that all soil below one foot has lower concentrations. But that is the linchpin assertion supporting the Notice of Intent to Delete VB/I-70 OU1.

The only depth-related data in the VB/I-70 OU1 area are data from within the shallowest 12 inches. There are two pertinent data sets with analyses from multiple depths. The more

⁷⁴ USEPA R8, 2019. Comments by USEPA R8 staff at its Quarterly Public Meeting on VB/I-70, March 12, 2019, Denver CO. In response to concerns expressed by citizens at the meeting over recontamination of properties due to digging associated with infrastructure projects, they were told that concentrations were highest at the surface of the yard. If no remediation had been done based upon 2-inch sampling, concentrations below that would be less and, therefore, not of concern. If there had been remediation, subsequent digging would not create recontamination because no anomalous concentrations existed below 12 inches.

extensive set are the data collected under the Phase I sampling protocols during the North Denver Residential Soils sampling in 1998.⁷⁵ During this sampling event there were 1,152 properties sampled with 2,363 analyses of surface samples (0" to 2") and 1,096 analyses of depth samples (6" to 10").⁷⁶ Eight of these properties were also investigated with soil borings sampled at two-inch increments from surface to 12 inches as part of the high-intensity investigative study prior to Phase III sampling.⁷⁷

Comparing the surface and depth analyses of the two populations of the Phase I sampling identifies no significant differences between the shallow and depth populations. There are virtually identical distribution patterns between the two sets of data for both arsenic and lead.⁷⁸ Minimally arsenic-impacted (< 70 mg/kg) samples constituted 88.1% of shallow samples and 88.4% of depth samples. Arsenic concentrations between 70 and 400 mg/kg represented 10.1% of the shallow samples and 10.6% of the depth samples. Minimally lead-impacted (< 500 mg/kg) samples constituted 96.5% of shallow samples and 95.8% of depth samples. Lead concentrations between 500 and 1000 mg/kg represented 3.1% of the both the shallow and depth samples. Among the worst of the worst, there might there be a difference. In the first round of Phase I testing, 46 properties exceeded the emergency removal threshold. Of those 46, 15% did not exceed the threshold at the surface and did exceed it in the deeper sample.

The tendency for the high-density sampling program to show highest concentrations at the surface is, in large part, an artifact of the residential properties selected for the study. Each of the impacted properties used in the study was selected only from the residences demonstrated to have decreasing concentrations with depth by the Phase I sampling.

Even on residential properties that were chosen because they had already demonstrated decreasing concentrations with depth, the trend is not universal or consistent. Thirty borings were taken from the five impacted properties studied. Only seven of the 30 borings declined continuously in arsenic concentrations and only six for lead. The peak arsenic concentration

⁷⁵ Sampling using the Phase I protocol was performed at later depths but it isn't clear whether the more recent use included sampling both at the surface and at depth.

⁷⁶ USEPA R8, 1998. Sampling Analysis for Site Removal Assessment, North Denver Residential Soils, Denver, Colorado. 6.0 Sample Results, Table 3.

⁷⁷ USEPA R8, 2001. Final Remedial Investigation, Part 3.2.1 p. 3-6.

⁷⁸ USEPA R8, 1998. Sampling Analysis for Site Removal Assessment, North Denver Residential Soils, Denver, Colorado. Tables 1 and 2.

occurred at the surface in 14 of the 30 locations and peak lead in 21 of 30 locations. Minimum arsenic occurred in the bottom of the cores in only 11 of the 30 borings and minimum lead in 13. Seventeen of the 30 locations (more than half) had lead concentrations increasing at the bottom of the core, as did 14 of 30 for arsenic.

6.2.3 Impacted Media below the 12-inch Shallow Soil

The VB/I-70 OU1 program remains inadequate, inappropriate, and non-protective of human health and the environment because it has not investigated media below the shallow soil that are likely to be contaminated primarily and/or are susceptible to contamination from the overlying shallow soil.

The CDOT investigations at the Brighton Boulevard and I-70 interchange established impacted fill below surface soils. Those impacts included organic and inorganic contamination at depths much greater than 12 inches. CDOT investigations also identified groundwater impacts consistent with the contaminants in the overlying fill. There is every expectation, given the history of widespread fill across VB/I-70 OU1, that similarly mobile contaminants exist elsewhere in fill under VB/I-70 OU1. Their existence will lead to similar cross-contamination of adjacent soils, soil water, and groundwater. Since fill contamination in VB/I-70 OU1 potentially exists anywhere within the fill, an investigation of soil must extend, at a minimum, to the base of the fill material. Groundwater must be investigated. Human health and the environment cannot be protected at VB/I-70 OU1 until the nature, the extent, and the mobility of those contaminants have been characterized and impacts thereof are mitigated.

USEPA R8 has a wealth of new information available to perform such characterization of soil, if it acts now. CDOT is again modifying its I-70 right of way. In the last year, CDOT has advanced thousands of borings into and through the fill from near the South Platte River to beyond the east edge of VB/I-70 OU1. CDOT publications of some of the data identify significant occurrences of smelter slag, metals and PAHs in the borings at some locations.⁷⁹ Although CDOT's interest has been contamination from a materials management perspective, the borings are archived and should be available for USEPA R8 to log and assess with respect to the potential of the fill to contaminate overlying and underlying media. USEPA R8 should take

⁷⁹ CDOT, 2018. Central 70 Soil Characterization Results (April 23 to August 29). Prepared by Kiewit meridian Partners and submitted to Colorado Bridge Enterprise c/o CDOT. October 12, 2018. 2974 pp.

advantage of these borings as a start point for further investigations into the character of the fill materials beneath VB/I70 OU1.

6.2.4 Non-time Critical Removal Threshold

The Phase I grab samples were subjectively taken at sites that were most likely to be contacted by the residents, *e.g.*, bare spots in lawn.⁸⁰ If the grab-sampled location were a “hot” spot for contamination, the sample might not represent an average concentration for the yard. The Phase II sampling, compositing five samples, was implemented to prevent emergency removal and replacement decisions based upon grab samples. The perceived risk was financial, *i.e.*, that properties that did not average above the time-critical threshold would unnecessarily be remediated. The result was that the 37 properties with surface grab samples that exceeded the time-critical thresholds were culled to 21 (57%) of the identified Phase I properties.⁸¹

A similar logic was applied for the Phase III sampling used to identify the non-time-critical eligibility for removal and replacement that was needed to remediate sites based upon chronic exposure. The performance objective was to ensure there was a less than 20% chance that a property with average soil concentration below the removal criteria would be remediated.⁸² As with the time-critical decision process, the level of compositing was used to mitigate the financial risk of unnecessary remediation.

The compositing protocol to reduce the incidence of implementing the remedy was similarly successful to that used for the time-critical compositing. Phase I (grab) sampling indicated, based upon a population of 1,152 properties, had 22.4% exceedance of the chronic exposure threshold.⁸³ Phase III (composite) sampling identified chronic exposure requiring remove and replace remediation on 814 properties (18.3%) of the 4,445 properties sampled, an almost 20% reduction.⁸⁴

⁸⁰ USEPA R8, 2003. Information Package for the EPA National Remedy Review Board, p. 5.

⁸¹ USEPA R8, 2003. Information Package for the EPA National Remedy Review Board, p. 5.

⁸² USEPA R8, 2003. Information Package for the EPA National Remedy Review Board, p. 13.

⁸³ USEPA R8, 1998. Sampling Analysis for Site Removal Assessment, North Denver Residential Soils, Denver, Colorado. 6.0 Sample Results, Table 3.

⁸⁴ Federal Register, Vol. 84, No. 25, IV. Basis for Intended Partial Site Deletion, Site Background and History, p. 2120.

Were the primary risk to residents of the impacted properties general exposure to all the residents, the averaging protocols may well have been appropriate. However, the acute and chronic thresholds were specifically focused on protecting a child with pica behavior, *i.e.*, a child who eats soil.⁸⁵ For this risk, an average across the yard is inappropriate. A child, particularly a child with pica behavior, does not graze for dirt across the yard. If it is opportunistic pica behavior, bare spots will disproportionately be eaten, because it is easier to reach the dirt. Phase I modeling established that bare spots had disproportionately high levels of contaminants, not average contaminant levels. If the pica behavior is driven by the taste of the soil, the distinctly sweet taste of lead would cause the child to focus on the areas with the most lead, not the average lead concentrations. Similarly, if the child is drawn to the tangy metallic and slightly sweet taste of arsenic, the child's selection will naturally focus on areas in the yard where that taste is strongest. In all cases, if the dominant risk scenario is considered to be a child with pica, it is inappropriate and not protective of the health of the child, to use an average level of contamination as the threshold when the exposure mechanism is biased toward the maximum concentration in the yard.

6.2.5 Protecting the Remedy

A new concept was becoming recognized at the time of the VB/I-70 OU1 program. By the early 21st century, we began to appreciate that a remedy can become ineffective with time if site conditions undermine it. The VB/I-70 OU1 program included an early element of the "protect the remedy" concept. In the case of the OU1 program, lead-paint abatement of buildings was used on some properties where there was a calculated risk that lead from the buildings could re-contaminate the shallow soils in the yards, re-creating with time a shallow-soil contamination problem.

For contaminants that are mobile, an investigation must completely characterize that mobility to understand contaminant transport and sequestration into and through the environment. Far too often, contaminant mobility is perceived as one-way attenuative processes that move contaminants downward from the surface and reduce the concentrations with reaction, dilution

⁸⁵ USEPA R8, 2003. Information Package for the EPA National Remedy Review Board, p. 23. The HHRA did evaluate a one-time exposure of a child with pica behavior to a patch of soil unusually high concentrations, but only with respect to a acute exposure. The vanishingly low probability of such incident means relying on it as a bounding condition is also inappropriate.

and or dispersion. Such conceptualization can create a false sense of security with respect to some remedies, particularly remove and replace.

For example, groundwater with a low (non-problematic) concentration of cadmium discharges at a valley wall where a bank of soil has an abundance of iron oxides. Through time, those iron oxides absorb so much cadmium from the groundwater that the bank sediments become dangerous to human health or the environment. The risk can be remedied by removing the cadmium-bearing sediments and replacing them with comparable sediments that do not have cadmium. The remedy is complete; the cadmium-rich soil is gone. But the fix is temporary. The dilute plume will continue to deposit cadmium onto the new sediments which will eventually again become toxic. The remedy is inappropriate because it is not protected and that is not protective of human health and the environment.

For contaminants that are soluble and that may become concentrated by uptake from ground- or vadose water, liquid and liquid/soil systems must be investigated. Lead and arsenic are such contaminants. There are multiple, well-documented mechanisms (physio-chemical, biologic, anthropogenic or some combination, as described above) that can readily move local, on-site contaminants from depth toward or to the surface.

Such mechanisms clearly function at VB/I-70 OU1. As demonstrated in Drexler's research, the solubilities of the arsenic and lead species found in the surface samples would have long ago dissolved the lead and arsenic to below the concentrations at which they now exist.⁸⁶ The contaminants clearly exist at the concentrations they do today because they are continually being transported or recycled to the surface from underlying source(s). The mechanisms responsible for contaminant transport from below must be an integral part of the investigation and evaluation of a contaminated Site to establish a remedy that is protected.

Arsenic and lead demonstrably found its way into the top 2-inches of some yards, where it was of health concern. Were the source of the contamination that it fell from the sky, or even from a garden spreader, and it no longer falls, the VB/I-70 OU1 remedy would be protected from being undone. But that is not how the lead and arsenic got into the top two inches of soil. The precise

⁸⁶ CDPHE, 1998, A Study on the Source of Anomalous Arsenic Concentrations in Soils from the Globeville Community – Denver, Colorado. 6.0 Arsenic from a Pesticide, p. 47 and Figure 16.

mechanism(s) that moved the arsenic and lead to the top of the yard from the fill beneath the yard has/have not been established. It may be different mechanisms at different yards. But, except for those properties where the source(s) of lead and arsenic serendipitously is/are entirely within the upper 12 inches, the transport mechanism(s) will simply recreate the original problem. *I.e.*, the remedy of the VB/I-70 OU1 program is not protected for arsenic and lead contamination. The remedy is not evaluated for other contaminants in the fill. When a remedy is not protected, it cannot be adequate, appropriate, or protective of human health and the environment, because the remedy is not permanent.

7.0 CONCLUSIONS

Much of the area of VB/I-70 OU1 was subject to dumping of fill materials through the decades following the arrival of railroads in the 1870s.

The neighborhoods of VB/I-70 have been subject to disproportionate impacts from many sources including industry, Superfund Sites, and major transportation corridors, any of which may have provided contaminated waste to random areas of VB/I-70 OU1.

Pre-Superfund CDOT investigations in areas overlapping VB/I-70 OU1 identified fill materials contaminated with PAHs, chlorinated and non-chlorinated VOCs, tannery wastes and smelter wastes and identified contaminated groundwater consistent with the soil contaminants.

Pre-Superfund research established that the lead and arsenic concentrations, associations and species distributions were inconsistent with speculations that the lead and arsenic contamination was due to homeowners use of a mid-20th century herbicide PAX.

Pre-Superfund investigations established the lead and arsenic distributions are inconsistent with patterns of aerial dispersal from smelter stacks but consistent with random fill of smelter wastes or of other arsenic- and lead-bearing wastes as random fill.

All sampling and investigations associated with the North Denver Residential Soils Site VB/I-70 OU1 programs were performed in shallow soils, *i.e.*, within 12 inches of the surface.

Attempts to draw meaningful conclusions about concentration profiles within the investigated one-foot of shallow soils are of dubious value in concept and are unconvincing in execution.

The mitigation of acutely high lead and arsenic concentrations on the surface of residential yards by removal and replacement of 12 inches of soil was defensible as a time-critical removal action emergency response for the properties most egregiously contaminated by those metals.

The acceptance and use of a Conceptual Model limiting lead and arsenic contamination to the disproven pair of air-fall from smelter stack and/or PAX application for the design the RI of VB/I-70 fatally flawed the investigation to the surface 2 inches of residential yard soils and only to arsenic and lead.

Building upon the fatally flawed RI, the rest of the VB/I-70 OU1 efforts – FS, HHRA, ROD, Remedial Objective and Remedial Implementation – was and remains inherently flawed.

The final remedy for VB/I-70 OU1 is transference of the time-critical removal action emergency response to the non-time critical response to areas of chronic exposure; the same solution but a different problem.

The VB/I-70 OU1 remedy of remove and replace for the uppermost 12 inches of residential soil does not remove, reduce, or address the source(s) of the arsenic and lead contamination. It removes only a surface expression of the source(s).

The VB/I-70 OU1 remedy is not protected; it is only temporary. Leaving the source(s) and transport mechanisms of the lead and arsenic intact will allow the shallow soil contamination by arsenic and lead to recur.

At the time of the ROD and in the ROD for VB/I70 OU1, it is acknowledged that smelter wastes in fill and that of other industries are contributing sources to the lead and arsenic contamination in the residential soils.

The VB/I-70 OU1 remedy does not investigate, assess, and address any of the other contaminants introduced with the fill materials beneath VB/I-70 OU1.

The VB/I-70 remedy does not investigate, assess, or address impacts from the fill materials at the Site on the water in the underlying alluvial aquifer of the Montclair Creek basin, a groundwater resource that is tributary water to the South Platte River and its alluvial aquifer, sources of public water supplies and irrigation water.

It is known now that the VB/I-70 OU1 remedy is incomplete, inadequate, and inappropriate. It is not protective of human health and the environment. There is no need to wait until some future time to address its inadequacies.

Rather than deleting VB/I-70 OU1 as a reward for implementing an ill-conceived remedy in search of a problem that never existed, USEPA R8 should go back to the Conceptual Model, redefine the problems of OU1, and go through the process again, meaningfully this time.

In the alternative, USEPA R8 should immediately designate VB/I-70 OU4, geographically coincident with VB/I-70 OU1, designated as addressing all contaminants introduced with the historic fill for all properties underlain by the fill and all media impacted by the fill contaminants.

While USEPA R8 redefines VB/I-70 OU1 or initiates VB/I-70 OU4, USEPA R8 should institute re-sampling of the properties previously subject to the remove and replace remedy to establish the rates at which the implemented remedy is being undone by processes under the surface and remediate those that have again become a threat to human health and the environment.

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Attachment 1

Resume of Charles H. Norris

Charles H. Norris, P.G.

summary of Qualifications

Forty plus years of professional experience in geology, hydrogeology and management in the applied and theoretical geosciences. Experience includes performance, oversight review, or management of site assessment; RI/FS; computer modeling of fluid flow, contaminant transport, and geochemistry (applications and code development); policy and rule-making procedures; aquifer evaluation; resource development; and litigation support; nationwide and internationally.

Professional Experience

Geo-Hydro, Inc., (1996-present), Principle, Officer, Co-owner
Hydro-Search, Inc., (1992-1996), Director of Hydrogeology
University of Illinois at Urbana-Champaign, (1987-1992), Research Associate; Manager, Industrial Consortium for Research and Education for the Laboratory for Supercomputing in Hydrogeology
Consulting Hydrogeologist/Geologist, Champaign, Illinois and Denver, Colorado, (1980-1992)
MGF Oil Corporation, (1985 - 1986), Manager Geological Engineering
Emerald Gas and Oil, (1980 - 1986), President and Owner
Petro-Lewis Corporation, (1980), District Geologist
Tenneco Oil Company, (1977-1980), Senior Geological Engineer
Amoco International Oil Company, (1975-1977), Senior Geologist
Shell Oil Company, (1972-1975), Exploration Geologist

Professional Registrations, Memberships, and Affiliations (a/o 20170206)

Professional Geologist: Illinois (196-001082), Indiana (2100), Georgia (PG002123), Kentucky (KY-2470), Missouri (2011012527), Pennsylvania (PG003994), South Carolina (2616), Utah (5532631-2250), Virginia (2801 001834), Wisconsin (No. 924), Wyoming (No. 2989)

Registered Environmental Professional (#5350), State of Colorado, Petroleum Storage Tank Fund

National Ground Water Association

Colorado Groundwater Association (Board Member (various years), Vice President 1999, President 2000, Past-President 2001)

Phi Beta Kappa, Phi Kappa Phi, Sigma Xi

Education

B.S., Geology, University of Illinois, High Honors and Distinction in Geology, 1969

M.S., Geology, University of Washington, National Science Foundation Fellow, 1970

University of Illinois, all but dissertation completed for Ph. D., Hydrogeology, 1992

Select Project Experience

RI/FS AND SITE INVESTIGATIONS

- Manager for technical assistance through a Technical Assistance Program (TAP) grant from PRPs to local citizens' group. Assistance through grant to provide assessment and feedback on site work products as they are developed and implemented, explain the remediation processes and activities to the citizens, and serve as technical liaison between citizens and remediation team.
- Modeler and hydrogeologic consultant at industrial tank farm adjacent to the Chicago Sanitary and Ship Canal in northeastern Illinois. Assess hydrogeologic data, interpret aquifer testing, and model groundwater flow in soil and fractured carbonate bedrock in area of DNAPL accumulation as part of site characterization and voluntary remediation design.
- Manager and Hydrogeologist of groundwater investigation at an industrial dump site adjacent to the Illinois River in north Central Illinois. Investigated fate and transport of 3-4 decades of disposal of mixed, hazardous industrial wastes at a non-engineered floodplain dump site. Expert testimony and legal support. Pre-trial settlement provided for installation of monitoring system in lieu of site characterization.
- Manager of groundwater flow modeling performed as part of the groundwater characterization effort and as part of the preliminary remedial designs. The site is a Superfund site involving both organic and metals contaminants at a wood treating facility in an urban area in Alabama adjacent to a major commercial waterway.
- Manager of groundwater flow modeling performed as part of the groundwater characterization effort and as part of the 90% and final remedial designs. The site is a high profile Superfund site involving both organic and metals contaminants at a wood treating facility in Northern California.
- Technical Advisor assisting in the evaluation of aquifer properties and well performances for an extraction well field near Sacramento CA. A high volume pump and treat system for chlorinated solvents showed strong and anomalous decline in productivity. Detailed evaluation identified both possible causes and recommended operations changes to alleviate the problems.
- Technical Advisor assisting in the evaluation of aquifer properties and well performances for initial installation of a high volume extraction well field in Southern California. The chlorinated solvent plume associated with a Superfund site impacted a large area in a layered, heterogeneous groundwater basin managed intensively for public water supplies.
- Senior oversight and review in the evaluation of aquifer and soil properties, and the remediation of the soils contamination and groundwater impacts associated with compressor facilities of interstate gas transmission companies. Various projects and sites in western Colorado, Wyoming, and the Texas panhandle.
- Technical Advisor for the Remedial Investigation/Feasibility Study (RI/FS) of the Landfill Solids and Gases Operable Units at the Lowry Landfill CERCLA site located near Denver, Colorado. This project involves the characterization of the extent of potential contamination within the unsaturated zone adjacent to this high profile site. Work involves extensive coordination and interaction with multiple PRP groups as well as various regulatory agencies.

- Project Manager for independent oversight of a proposed low-level radioactive waste disposal site. Task was to develop technical and legal program for governmentally funded intervenor's case as part of adjudicatory hearings on a high-profile, proposed disposal facility and involved identifying, retaining and educating legal staff, retaining a team of technical experts, negotiating fees, coordinating work product and presentations, providing liaison with citizen's groups, responding to press and integrating personal testimony on hydrogeology and modeling. Expert testimony and legal support.

Landfill Services

- Project Manager and Hydrogeologist for a geologic and hydrogeologic assessment of existing water quality and off-site migration from existing licensed landfill near Joliet IL. Work includes groundwater flow modeling of remedial alternatives and groundwater impact assessments of various alternatives for submittal to IEPA.
- Project Manager and Hydrogeologist for a geologic and hydrogeologic assessment for siting of a proposed expansion for a hazardous waste landfill in Peoria County, Illinois. Expert testimony and legal support. Review identified errors in application, unaddressed contamination on facility property, and inappropriate modeling design and implementation.
- Project Manager and Hydrogeologist for a geologic and hydrogeologic assessment for siting of a proposed regional landfill by expansion of local landfill in Ogle County, Illinois. Expert testimony and legal support. Review identified in errors application, unaddressed existing leakage, and potential risk to public water supply. (Three hearings)
- Project Manager and Hydrogeologist for a geologic and hydrogeologic assessment for siting of a proposed regional landfill by expansion of local landfill in Kankakee County, Illinois. Expert testimony and legal support. Review identified errors in application, unaddressed existing off-site leakage, and inappropriate modeling design and implementation. (Two hearings)
- Project Manager and Hydrogeologist for a geologic and hydrogeologic assessment of a proposed regional landfill in Will County, Illinois. Expert testimony and legal support. Research documented numerous errors in application which resulted in underestimation of infiltration rates and potential migration rates. Identified evidence of sub-karstic migration pathway from site to nearby stream.
- Project Manager and Hydrogeologist for a geologic and hydrogeologic assessment of a proposed regional landfill expansion at East Peoria, Illinois. Research documented current leakage from the existing landfill into the regional unconfined aquifer within the cone of depression of the municipal water supply wells. In part as a result of the evaluation, the proposed expansion has been abandoned. Expert testimony and legal support.
- Project Manager and Hydrogeologist for a geologic and hydrogeologic assessment of a proposed regional landfill at Ottawa, Illinois. Provided testimony at county hearings identifying and documenting site-specific conditions that invalidated part of the ground water evaluation testing, necessitating the need to re-evaluate the groundwater flow system and redesign the monitoring system. Expert testimony and legal support.
- Project Manager and Hydrogeologist for a geologic and hydrogeologic assessment of existing municipal landfills and a proposed landfill redesign and expansion at Salem, Illinois. Provided testimony at city hearings documenting existing landfill leakage and identifying site-specific conditions that complicate the design of a reliable monitoring system. Expert testimony and legal support.

- Project Manager and Hydrogeologist for site evaluations of the geology and hydrogeology of several proposed municipal landfills and a landfill expansion in Bartholomew County, Indiana. The review of the expansion demonstrated inadequate monitoring of the existing facility. One proposed site showed possible, current ground water usage from under the proposed facility and conditions that may preclude state-level site approval.
- Project Manager and Hydrogeologist serving in consultation to the Board of Wayne County, Illinois, regarding a proposed expansion to a regional landfill. Investigation and oversight established viability of the physical site and improvements that were needed in operating procedures and monitoring efforts. Expert testimony and legal support.
- Project Manager and Hydrogeologist for an assessment of an existing regional municipal landfill at Urbana, Illinois. Principle problems included ground water contamination, unplugged well(s) within the facility boundary that penetrated the aquifer serving public water supplies and a monitoring system inadequate to evaluate the contaminant migration. Results of the evaluation include an expanded system of monitoring wells, improved protocols for ground water sampling and revised statistical procedures to determine background water chemistries.
- Project Manager and Hydrogeologist for a site assessment of a proposed municipal landfill expansion in west central Indiana. Established feasibility of using the engineering and design features of the expansion to prevent contamination from the pre-existing non-engineered facility.
- Project Hydrogeologist for a site assessment of a proposed saturated-zone, regional balefill in central Illinois. Principal problems involved the evaluation of the hydrogeologic characteristics of the strip mine spoils within which excavation would occur, the blasted mine bottom upon which the liners would be built and the materials available for liner construction. Expert testimony and legal support.
- Project Manager and Hydrogeologist for a site assessment of a proposed municipal landfill expansion in Livingston County, Illinois. Principal problems involved the evaluation of the impact of shallow coal tunnel mining beneath the site and reaction of waste leachate with unusual clay mineralogy important to waste isolation at the site. Expert testimony.
- Technical Reviewer of site assessment and re-assessment of a proposed inter-governmental regional landfill in central Illinois. Verified unanticipated, politically unacceptable risks to major aquifer system serving public water supplies. Assisted in drafting of technical policy statement that permitted new siting efforts to proceed in the jurisdiction. Expert testimony.

WATER RESOURCE EVALUATION & DEVELOPMENT

- Manager for ground water modeling effort associated with the development of a high-volume ground-water supply and delivery project in Colorado. The effort included investigating and evaluating a previously used, court-accepted model, adapting and updating the model, and applying the model to assess the impacts of a proposed private ground-water diversion project that would be the largest in the United States. Ongoing effort includes subsequent review of alternative proposed model and further litigation support.
- Manager for review of an application for an expansion of a large long-wall mine in southeastern Ohio. The review identified extensive unrecognized mining-related impacts to water supplies from historic mining and identified hydrologic risks to a unique old-growth forest adjacent to the proposed expansion, and resulted in an appeal of the application. Expert testimony and legal support.

- Manager for ground water modeling effort associated with the development of a surface reservoir designed for conjunctive use of ground and surface water to reduce peak ground water pumping demands in Denver metro area. The effort included investigating and evaluating a previously used, model, adapting and updating the model, and applying the model to assess the impacts of project on other water rights. Study is a component of the EIS.
- Project Manager for multi-company effort to model thermal loading of northern Nevada surface waters as a result of mine dewatering project. Successful liaison among technical staffs and regulators and modeling work for a high profile EIS resulted in approval of discharge permit.
- Project Hydrogeologist for the feasibility study of a small lake for a northern Illinois nursery, to be used for recreation, fishing and irrigation. Evaluated shallow and intermediate ground water and surface run-off, reviewed engineering design and directed ground and surface water sampling program to determine nutrient levels.

Hydrochemistry

- Principal Investigator for grant to research the geochemical implications of using alkaline addition as one means for preventing and/or remediating inorganic contamination resulting from acid mine/rock drainage. Empirical and modeling evidence showed conditions under which alkaline addition can cause or exacerbate contamination of some constituents of concern.
- Project Manager, hydrogeologist, geochemist for ongoing investigation of metals contamination of a trout stream in West Virginia. Impacts from natural and industrial sources, present and past, evaluated to segregate relative significance of various sources. Includes expert testimony and legal support.
- Project Geochemist and Hydrogeologist for evaluation and critique of modeling protocols used by USEPA for risk assessments performed as part of regulatory determinations for various solid wastes. Identified errors in methodology and input that had caused previous modeling to mischaracterize risks for settings with observed damage cases. Computer modeling.
- Geochemist and Hydrogeologist for evaluations of inorganic groundwater chemistry at an industrial RCRA site near Joplin MO. Federal lawsuit filed pursuant to PRP contribution and sources and timing of contamination. Was able to use geochemical interpretations to establish significant elements of aquifer characteristics and implications for contamination routes. Expert testimony.
- Project Hydrogeologist and Geochemist for evaluations of proposed coal combustion waste disposal as part of reclamation activities at surface coal mines in Southwestern Indiana. Ongoing efforts are targeted toward refining regulatory framework for disposal efforts, establishing effective characterization and monitoring programs and determining appropriate operation and engineering practices. Project involves extensive interdisciplinary effort and expert testimony.
- Project Geochemist for the investigation of the impacts of remediating acid mine drainage by installing bulkheads to flood exhausted mine working. Predictively modeled water chemistries in situ, within flooded mine, along flow paths and upon surface discharge. Assisted in preparation of testimony that resulted in permit approval for the San Juan County, Colorado project.
- Project Manager and Project Geochemist/Hydrogeologist for investigation of potential environmental impacts of disposal of coal combustion wastes (CCW) as part of a reclamation plan at a surface coal mine in northern New Mexico. Performed or directed geochemical, infiltration and flow modeling of the proposed project to identify optimum disposal methods and worst case impacts. Presentation to State resulted in approval of this precedent-setting project.

- Project Manager, Geochemist and Hydrogeologist for an investigation of a proposed disposal/construction project to build a central Illinois ski mountain from fly ash produced by a co-generating plant operated by a major food products manufacturer. The investigation involved overseeing an engineering review of project plans, a site investigation and evaluation, geochemical modeling of initial and final mineralogical composition of the mass and of the leachate chemistry and evolution and the impact on the hydrogeologic and structural integrity of the project. Expert testimony and legal support.

Petroleum Industry Experience

- Project Manager for the environmental assessment of 82 Texas producing properties targeted for acquisition. Evaluations included site walk-overs, surface soil and liquid sampling, radiological monitoring and geoprobe sampling of soils and ground water. The assessments documented a multitude of impacts from both exempt and non-exempt wastes that, unrecognized, could have resulted in substantial financial exposure to the client.
- Project Geologist and Petrophysicist for an investigation of resource potential of coal bed methane in San Juan Basin of New Mexico and Colorado. Study focused on innovative log analysis techniques; formation water chemistries, production rates and disposal problems; well drilling, completion and re-completion practices; and detailed subsurface facies and structural mapping and stratigraphic correlation in shallow coal beds of Kirtland/Fruitland/Pictured Cliffs shoreline complex and relationships to overlying Tertiary sandstones.
- Developed a successful play in the Hunton and Mississippi Lime formations of northwest Oklahoma. The play recognized the secondary porosity systems of both formations (dolomitization and fracturing, respectively) and the genetic significance to each of the buried topography at the intervening unconformity.
- Managed a detailed reservoir study of a Cotton Valley gas field in east Texas that resulted in RRC approval of non-standard spacing based upon the recognition of secondary porosity and a dual-conductivity system that resulted from drape-induced fractures. The revised spacing both protected resource ownership and conserved the costs of infill drilling. Expert testimony and legal support.
- Project Geologist, Petrophysicist and Expert for various contested adjudicatory hearings apportioning oil and gas ownership. Cases involved primary recovery of both oil and gas and secondary recovery of oil. Accepted as expert (geology, hydrogeology, and/or geological engineering) in Oklahoma, Texas, and Wyoming.

Additional Professional Experience

- Invited presenter to National Research Council of the National Academy of Sciences, Committee on Mine Placement of Coal Combustion Wastes.
- Appointed member of a Quality Assurance Committee under the West Virginia Department of Environmental Protection. The committee, comprised of representatives of state and federal regulators, industry, and interveners, was charged with a year-long review of state mining applications and approval practices relative to mining under the state and federal surface mining laws.
- Invited presenter to National Research Council of the National Academy of Sciences, Subcommittee on Alternatives, Study on Coal Waste Impoundments.

- Project Manager and Hydrogeologist for the review of Proposed and Revised Proposed Criteria for the Siting of a Low Level Radioactive Waste Disposal Facility in Illinois. Evaluation was targeted toward both technical content and processes of selection. Testimony and written comments led to significant improvements and flexibility in the Criteria as finally published.
- Project Hydrogeologist testifying at hearings before the Illinois Pollution Control Board on regulatory language for the Illinois Ground Water Protection Act. Contributed major conceptual and specific language changes to the final promulgated rules for Ground Water Quality Standards and Regulations for Existing and New Activities with Setback Zones and Regulated Recharge Areas. Expert testimony and legal support.
- Project Hydrogeologist and Log Analyst for three applications to U.S. EPA for permits to continue deep well disposal of hazardous wastes in east central Illinois and southern Ohio. Project required evaluation of geophysical logging data to determine injection zone and confining layer properties, regional flow systems, chemical interactions of the waste stream with the native rock and the ability of the injection system to isolate the waste from the environment.

Reports, Presentations, and Publications

- Norris, Charles H., 2005, "Water Quality Impacts from Remediation Acid Mine Drainage with Alkaline Addition", draft version released to National Research Council of the National Academy of Sciences, Committee on Mine Placement of Coal Combustion Wastes, Geo-Hydro, Inc., Denver CO, July 3, 2005
- Norris, C. H., "notes from the front. . . Overview of three sites", invited paper before National Research Council of the National Academy of Sciences, Committee on Mine Placement of Coal Combustion Wastes, Evansville IN, March 2005.
- Norris, Charles H., 2004, "Environmental Concerns and Impacts of Power Plant Waste Placement in Mines", Presented at Harrisburg PA, May 4-6, 2004. Published in Proceedings of State Regulation of Coal Combustion By-Product Placement at Mine Sites: A Technical Interactive Forum, Kimery C Vories and Anna Harrington, eds, by U. S. Department of Interior, Office of Surface Mining, Alton IL, and Coal Research Center, Southern Illinois University, Carbondale IL.
- Norris, C. H., "Developing Reasonable Rules for Coal Combustion Waste Placement in Mines. Why? When? Where? How?", USEPA Contract 68-W-02-007, IEI Subcontract 7060-304, Invited paper at USEPA MRAM meeting, Rosslyn VA, September, 2003.
- Norris, C. H., "So, You Think You're a Geologist? (F. Kafka to A. Liddell, In Wonderland)", Colorado Ground Water Association Monthly Meeting,, Denver CO, September, 2002.
- Norris, C. H., "Assessment of the Anker Energy Corporation proposal for mining and reclamation, Upshur County, West Virginia." Independent evaluation on behalf of Anker Energy Corporation and West Virginia Highlands Conservancy, July, 2002.
- Norris, C. H., "Coal Combustion Waste: Coming soon to a neighborhood (and maybe a faucet) near you." Colorado Ground Water Association Monthly Meeting, Denver CO, May, 2001.

- Norris, C. H., "Slurry-to-ashes, and ashes-to . . . A case of a coal company and citizens working together to evaluate alternatives." Invited paper before National Research Council of the National Academy of Sciences, Subcommittee on Alternatives, Study on Coal Waste Impoundments, St. Louis MO, June, 2001.
- Norris, C.H., and C. E. Hubbard, "Use of MINTEQA2 and EPACMTP to Estimate Groundwater Pathway Risks from the Land Disposal of Metal-Bearing Wastes", for Environmental Technology Council, submitted as public comment to USEPA on regulatory determination for Fossil Fuel Combustion Wastes, May, 1999.
- Norris, C.H., "Report on the Determination of Intermittent Streams and the Potential Impacts of Valley Fill on Area Drainages, Southern West Virginia", expert report for litigation prepared for Mountain State Justice, Inc, Charleston WV, March, 1999.
- Norris, C.H., "Report on the Geology and Hydrogeology of the Caterpillar Levee Site with an Evaluation of Potential Pathways on- and off-site for the Movement of Solid and Hazardous Wastes", expert report for litigation prepared for Citizens for a Better Environment, Chicago IL, March, 1998.
- Norris, C.H., "Dr Pepper, Biorhythms, and the Eight-Hour Pumping Test ", Colorado Ground Water Association Annual Meeting, Golden CO, December, 1997.
- Norris, C.H., "Characterizing Ash Composition and (vs.) Projecting Environmental Impact for Purposes of Permitting CCW Disposal ", Coal Combustion By-Products Associated with Coal Mining - Interactive Forum, Southern Illinois University at Carbondale, Carbondale IL, October, 1996.
- Norris, C.H., "Geochemical Modeling". Co-instructor for Short Course on Hydrogeologic Issues Related to Mine Permitting, Reclamation and Closure, SME Annual Convention, Phoenix AZ; March, 1996.
- Norris, C.H., An Improved Method for Middle Time Analysis of Slug and Bail Test. Unpublished. 1994.
- Norris, C.H., "Evolution of the Landfill", presentation as part of a Telnet program, *Garbage Dilemma Educational Series*, sponsored by Illinois Farm Bureau and Cooperative Extension Service of the College of Agriculture, University of Illinois, Urbana, Illinois, April 20, 1992.
- Norris, C.H., "Technical Analysis or Political Acceptability: The Domesticated Fowl or its Ovum", Solid Waste Management and Local Government Workshop, sponsored by Institute of Government and Public Affairs, University of Illinois, Urbana, Illinois, Jan-Apr, 1992.
- Norris, C.H., Report on the Geology and Hydrogeology [of the] SWDA Proposed Landfill Site, Township 8 North, Range 6 East, Section 31, Bartholomew County, Indiana, for Central States Education Center, Champaign, Illinois, 1991.
- Norris, C.H., Hydrogeology and Modeling of the Proposed Illinois Low Level Radioactive Waste Disposal Site at Martinsville, Illinois; testimony before the LLRW Siting Commission, October and November, 1991, Martinsville, Illinois.
- Norris, C.H., Ground Water Quality Standards for the Illinois Ground Water Protection Act; testimony before Illinois Pollution Control Board, Chicago, Illinois; February, May, October and December, 1990; May, 1991.

Norris, C.H., Hearing on a Petition for a Special Use Permit for the Construction of a Ski Mountain in Oakley Township, Macon County, Illinois; testimony before the Macon County Zoning Board of Appeals; February 16, 1990.

Norris, C.H., Hearing on a Solid Waste Disposal Permit for the Siting of a Municipal Landfill for Streator, Illinois; testimony before the Livingston County Board; August 6, 1990.

Norris, C.H., In the matter of the Gallatin National Company Proposed Balefill, Fulton County, Illinois, written comments to the Illinois Environmental Protection Agency, Springfield, Illinois, 1990.

Norris, C.H., 1990, Log Analysis of the Allied Chemical Corporation Waste Injection Well, Danville, Illinois, for Alberto Nieto, Champaign, Illinois.

Norris, C.H., 1989, Log Analysis of the Cabot Corporation Waste Disposal Wells, Tuscola, Illinois, for Alberto Nieto, Champaign, Illinois.

Norris, C.H., Regulations for Existing and New Activities Within Setback Zones and Regulated Recharge Areas for the Illinois Ground Water Protection Act; testimony before Illinois Pollution Control Board, Chicago, Illinois, June, 1989.

Norris, C.H., and C.M. Bethke, (Abstract) "Mathematical Models of Subsurface Processes in Sedimentary Basins", Conference on Mathematical and Computational Issues in Geophysical Fluid and Solid Mechanics, Society for Industrial and Applied Mathematics Annual Meeting, Houston, Texas, September 28 (invited paper), 1989.

Norris, C.H., "An Evaluation of the Geology and the Monitoring Well Data [at the] City of Urbana Regional Landfill", report submitted to the City of Urbana, Champaign County, Illinois, for Central States Education Center, Champaign, Illinois, 1989.

Norris, C.H., Gallatin National Proposed Balefill/Landfill [at] Fairview, Illinois; testimony before Fairview Town Council, Fairview, Illinois, November, 1988.

Norris, C.H., "Evaluation of the Hydrogeologic Factors Influencing Risk [at the] ISWDA Regional Landfill Site B", report submitted to the Inter-Governmental Solid Waste Disposal Association, Champaign County, Illinois, 1988.

Norris, C.H., and C.M. Bethke, "Status and Future Directions of Quantitative Flow Modeling in Sedimentary Basins", Workshop on Quantitative Dynamic Stratigraphy (QDS), Colorado School of Mines, Lost Valley Ranch, Colorado, February 14-18, 1988.

Attachment 2

Documents Reviewed

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CDOT, 1998. Final Site Investigation I-70 Phase II and III Construction, 44th Street to Brighton Boulevard, City and County of Denver. Prepared by Walsh Environmental Scientists and Engineers, Inc., July 23, 1998. 221 pp.

CDOT, 1998. Final Materials Management Plan Phase II and III Construction, I-70 Modifications Humboldt/44th Streets to Brighton Boulevard, Denver, Colorado. Prepared by Walsh Environmental Scientists and Engineers, Inc., July 24, 1998. 38 pp.

CDPHE, 1998, A Study on the Source of Anomalous Arsenic Concentrations in Soils from the Globeville Community – Denver, Colorado. Prepared by John W. Drexler, June 9, 1998. 151 pp.

CDPHE, 2018. Letter to USEPA R8: Concurrence of Partial Deletion of Vasquez Boulevard and I-70 Superfund Site. From Jennifer T. Opila (CDPHE) to Betsy Smidinger (USEPA R8), November 2, 2018. 1 p. [EPA deletion document 75]

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US Army Corps of Engineers, 2005(?). Final Site Report, Vasquez Boulevard/Interstate 70, Denver, Colorado, July 18, 2003 through March 29, 2004. Prepared by PRI, 2005(?). [EPA deletion document 64]

US Army Corps of Engineers, 2008. Final Site Report Addendum Number 1, Vasquez Boulevard/Interstate 70, Denver. Prepared by PRI, August 2008. 34 pp. [EPA deletion document 65]

US Army Corps of Engineers and USEPA R8, 2016. Final Institutional Control Implementation and Assurance Plan, Vasquez Boulevard/Interstate 70, Operable Unit 1 – Residential Soils, Denver, Colorado, CERCLIS ID: CO0002259588. Prepared by CB&I Federal Services LLC. November 9, 2016. 22 pp. [EPA deletion document 62]

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USEPA R8, 1998. Sampling Analysis Report for Removal Site Assessment, North Denver Residential Soils, Denver, Colorado. Prepared by URS Operating Services, Inc., for USEPA START [Superfund Technical Assessment and Response Team] Region VIII, July 6, 1998. 166 pp.

USEPA R8, 1998. Action Memorandum: Request for Time-Critical Removal Action at Vasquez Boulevard and I-70 (aka North Denver Residential Soils) Site, City and County of Denver, Colorado. Denver CO. September 16, 1998. 24 pp.

USEPA R8, 1999, Project Plan for the VB & I-70 Site Pilot-Scale Soil Characterization Study, Denver CO, September 9, 1999, prepared by ISSI Consulting Group, Inc.

USEPA R8, 2001, Remedial Investigation VB/I-70 Site Operable Unit 1 Final, Denver CO, prepared by Washington Group International, July 2001. 432 pp.

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USEPA R8, 2001. Baseline Human Health Risk Assessment, Vasquez Boulevard and I-70 Superfund Site, Denver CO. August 2001. 170 pp. [EPA deletion document 58]

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USEPA R8, 2004. Remedial Design Work Plan for Soil Sampling and Remediation Program, Operable Unit 1, Vasquez Boulevard/Interstate 70 Superfund Site, Denver, Colorado. Prepared by MFG, Inc., Tetra Tech EM Inc. and Project Resources Inc., July 2004. 302 pp. [EPA deletion document 71]

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USEPA R8, 2013. Remedial Design Work Plan for Soil Sampling and Remediation Program, Operable Unit 1, Vasquez Boulevard and I-70 Superfund Site, Denver, Colorado. Prepared by MFG, Inc. and Tetra Tech EM Inc, edited by Shaw Environmental & Infrastructure, Inc. July 1, 2013. 193 pp. [EPA deletion document 70]

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